AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

THE RELATIONSHIP BETWEEN
PHYSICAL ACTIVITY AND PRODUCTIVITY

MAJOR GARY S. BOYLE
MAJOR JAMES C. CLEM #84-0275

"insights into tomorrow"

DISCLAIMER

REPORT NUMBER #84-0275

TITLE
THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND PRODUCTIVITY

AUTHOR(S)
MAJOR GARY S. BOYLE, USAF
MAJOR JAMES C. CLEM, USAF

FACULTY ADVISOR
LT COL LEONARD G. VANDEVENDER, ACSC/EDOWD

SPONSOR
LT COL HARRY P. WETZLER, DOD/MERB

Submitted to the faculty in partial fulfillment of requirements for graduation.

AIR COMMAND AND STAFF COLLEGE
AIR UNIVERSITY
MAXWELL AFB, AL 36112

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 84-0275	2. GOVT ACCESSION NO. AD-A143	3. RECIPIENT'S CATALOG NUMBER 335
4. TITLE (and Subtitle) THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND PRODUCTIVITY		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Gary S. Boyle, Major, USAF, [redacted] James C. Clem, Major, USAF,		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS ACSC/EDCC, MAXWELL AFB AL 36112		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS ACSC/EDCC, MAXWELL ABB AL 36112		12. REPORT DATE April 1984
		13. NUMBER OF PAGES 133
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

STATEMENT "A"

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Contains copyrighted material

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains a comprehensive review of the literature relating physical activity to productivity within the context of a theoretical model. The report also describes the results of cross-sectional analyses of survey data on physical activity in national samples weighted to match USAF demographies. The results revealed little difference between levels of physical activity and health-related measures of productivity.

DD FORM 1 JAN 73 1473

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

PREFACE

This study addresses the relationship between physical activity and productivity. Chapter One presents a general introduction to the research study. In Chapter Two, the literature relating physical activity to productivity is reviewed. Chapter Three contains cross-sectional analyses of data on physical activity and productivity from two national surveys weighted to match USAF demographic characteristics. Finally, in Chapter Four, conclusions and recommendations based on the literature and survey analyses are presented.

The authors gratefully acknowledge the assistance received from many people with special knowledge on this subject. Several people deserve special recognition for their important contributions. Lieutenant Colonel Harry P. Wetzler, USAF, MC, originally suggested the need for this research and served as the official sponsor of the project. His advice gave perspective to our research. He also provided immeasurable aid in the survey analyses. Lieutenant Colonel Leonard G. Vandevender, USAF, offered numerous helpful suggestions as our advisor. Captain Jeffrey S. Austin, USAF, of the Leadership and Management Development Center (LMDC) served unofficially yet willingly as our technical advisor. He made important contributions which helped to focus and clarify our research. We deeply appreciate their substantial investment in both time and effort to this project.

Also, we are thankful for permission to reproduce and use certain copyrighted material. We are grateful to Messrs. Folkins and Sime for permission to use Tables 1, 2 and 3, and to Messrs. Howard and Mikalachki for use of Figures 1, 2, 3 and 4.

This study follows the format specified for LMDC technical reports and the American Psychological Association Publication Manual. Use of this format will enhance the utility of this study and may facilitate publication in journals in the future.

ABOUT THE AUTHOR

Major Gary S. Boyle helped prepare this study while a student at the Air Command and Staff College (ACSC), Maxwell AFB, AL. He has worked primarily as a personnel officer in previous assignments. In his last assignment, he served as Chief, Executive Services Group, DCS/Manpower & Personnel, HQ USAF. Earlier in his Pentagon tour, he was the Executive Officer, OSAF/Space Systems. He has also served as a personnel officer at the Air Force Manpower and Personnel Center, Randolph AFB, TX., Yokota AB, Japan, and Grissom AFB, IN. He earned his bachelor's degree in psychology at the University of Notre Dame in 1972. He was also awarded a master's degree in systems management by the University of Southern California in 1977. He has a wife, Sheryl, and a son, Ryan, age 7.

Major James C. Clem also helped complete this study while a student at ACSC, Maxwell AFB, AL. A C-130 Navigator, his most recent assignment was in the Defense Logistics Agency as a Flight Test Evaluation Officer at DCASPRO Hayes Birmingham, Al. He has also been assigned to CCK AB, Taiwan, Dyess AFB, TX, and Clark AB, Philippines as a Navigator. He holds a bachelor's degree in Industrial Management completed in 1969 from the University of Alabama and a MBA degree from Samford University completed in 1981. He has a wife, Celia, and a daughter Stephanie, age 10.

TABLE OF CONTENTS

CONTINUED

APPENDICES

LIST OF ILLUSTRATIONS

TABLES

CONTINUED

FIGURES

CONTINUED

EXECUTIVE SUMMARY

REPORT NUMBER 84-0275

AUTHOR(S) MAJOR GARY S. BOYLE, USAF
MAJOR JAMES C. CLEM, USAF

TITLE THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND PRODUCTIVITY

I. Problem: The USAF is seeking research that investigates the suggested benefits of fitness, particularly better performance and productivity on the job. The physiological benefits of regular aerobic exercise have been extensively documented. The research, however, only suggests the other assumed benefits of mental health, increased productivity and overall personal success. If research yields the predicted results, it may help persuade a substantial number of USAF personnel to obtain regular aerobic exercise, with a corresponding improvement in USAF productivity.

II. Objectives: The objective of this research was to evaluate the effects of regular physical activity on worker productivity.

CONTINUED

Aerobic exercises were the primary type of physical activity considered. The research focused on two specific objectives: (1) to review and analyze research on the influence of physical activity upon job productivity, and (2) to make cross-sectional analyses of existing survey data on physical activity and productivity in national samples matched to the demographic characteristics of USAF military personnel.

III. Method: A theoretical model describing the interaction of physical activity and productivity was identified by reviewing the professional literature on this topic. Then, the literature was analyzed, using the theoretical model as a framework. The model indicated that physical activity is most likely to influence productivity through the long-term benefits of better health. This hypothesis was examined by cross-sectional analyses of physical activity, as measured by self-reported assessments of exercise frequency, and productivity, as measured by number of lost workdays for illness or injury, days of hospitalization, days ill or injured in bed and number of doctor visits. These measures of productivity reflect to some degree on absenteeism rates and health care costs which the literature supports as valid, though selective, measures of productivity.

IV. Results: The theoretical model accounted for the substantive

CONTINUED

results in the literature on physical activity and productivity. In jobs inducing high mental and physical fatigue, the effects of physical activity on worker productivity are likely to be positive and evident in the short run. Obviously, the number of such military jobs would increase dramatically during wartime. If readiness requirements are considered, a substantial number of military jobs in peacetime would also have to be placed into this category. Otherwise, the longer term effects of physical activity on attitudes and feelings and health must be considered. Research shows the positive impact of physical activity on attitudes and feelings. However, the linkages between attitudes and feelings and commitment, loyalty, job satisfaction and productivity remain largely theoretical; this seriously inhibits assessment of the psychological benefits of physical activity in an occupational setting. The literature also strongly indicates that physical activity reduces the risk of heart disease and illness and injury. These positive health effects often have been reflected in reduced absenteeism and turnover. The survey analyses revealed little difference between levels of physical activity and the selected measures of productivity: lost workdays, days of hospitalization, sick days and doctor visits. In one survey, when physical activity was combined with other

CONTINUED

common health habits, several of the anticipated associations with productivity were found. As the number of health habits increased, the respondents had fewer lost workdays, days of hospitalization and doctor visits. This may indicate that physical activity and other health habits are interrelated and that in combination there is a synergistic effect on productivity. Comparison with available USAF survey data suggests similar results would be obtained in a USAF sample.

V. Conclusions and Recommendations: The literature consistently indicates that the health benefits of exercise, both in the short and long term, outweigh the risks of inactivity. However, it was difficult to discern any effects of regular physical activity on health-related measures of productivity, perhaps because of the USAF's youthful and healthy population. Still, the literature and some of the survey results suggest that physical activity may have positive effects on productivity through the synergism created by combining physical activity with other health habits. This synergistic effect appears to be strong enough to influence productivity, even in a youthful and healthy population. It is recommended that the USAF: (1) develop fitness standards based on wartime requirements for skills requiring high energy, (2) sponsor further research on the influence of physical activity on

CONTINUED

energy, stress, attitudes and feelings, and health, and (3) encourage military and civilian personnel to adopt and maintain a healthy lifestyle, including regular physical activity.

CHAPTER ONE

INTRODUCTION

Background of Problem

> Our Armed Forces must be mentally and physically prepared at all times, leaving no doubt about this nation's will and ability to defend itself. For this reason, it is necessary to reaffirm the importance of physical fitness...to maintain a high level of physical strength, endurance, and mental toughness as befitting an American fighting force (President Reagan, 1982).

The United States Air Force (USAF) traditionally has encouraged its military personnel to develop and maintain physical fitness. In the USAF's view, regular physical conditioning and a balanced diet will keep weight down, ensure proper weight distribution, lessen the chance of heart problems, reduce fatigue and make members more energetic and productive (AFR 35-11, 1981). In practice, it has been the individual's responsibility to comply with specified fitness standards through a personal conditioning program. The USAF, in 1962, began encouraging participation in a program patterned after the Five Basic Exercises (5BX) plan of the Royal Canadian Air Force, emphasizing calisthenics and running exercises (Luigs, 1972). Then in 1969, the USAF began advocating cardio-respiratory exercises, such as, running, cycling and swimming, based on the aerobics program (Cooper, 1968). In response to the President's request for an assessment of the Services' physical fitness programs, Department of Defense Directive 1308.1, Physical Fitness and Weight Control, was published in 1981; it requires each Service to implement a physical fitness program and to provide periodic assessments of the physical fitness of military members. The USAF, at present, is testing an enhanced, though still aerobics-oriented, version of the physical fitness program (AFMPC , 1983).

Significance of Problem

The USAF enhanced fitness program is based on the premise that increased fitness would improve total force readiness and the well-being of all military members without undue risk (AFMPC , 1983). This is essentially the same premise upon which the USAF has always advocated fitness. According to the USAF (Appendix A), the physiological benefits of regular aerobic exercise, which had been assumed for sometime, have now been extensively documented. Some of these physiological benefits are lower body fat, cholesterol level and blood pressure (Cooper, 1982). The research, however, only suggests the other assumed benefits of mental health, increased productivity and overall personal success. Perhaps in part because of the lack of this evidence, the USAF has found many military personnel appear to have adopted a "wait-and-see" attitude about regular exercise. For instance, only 50 percent of USAF military personnel see physical condition as important to performance in even half of USAF jobs. This attitude also is reflected in reported behavior; only one third of USAF military personnel said they exercise year round and only one quarter participate in some form of strenuous exercise four or more times per week (AFMPC , 1977). Thus, if the premise of the USAF's fitness program is correct, substantial benefits for both the organization and the individual can be reaped by persuading the rest of USAF personnel, both military and civilian, to exercise regularly.

The USAF is seeking research that investigates the suggested benefits of fitness, particularly better performance and productivity on the job. If a strong link between fitness and productivity is established, the evidence would apparently be used to convince more military members of the importance of regular exercise, as well as to support higher fitness standards. However, conclusive evidence of this relationship between fitness and productivity apparently is not available, though it seems to be widely accepted.

Anecdotal reports in the mass media by doctors, athletes, fitness enthusiasts and researchers appear to have contributed to the widespread impression that physical fitness does improve health, appearance and productivity. In business and industry, billions of dollars are spent annually - by over 50,000 firms in the U.S. alone - on employee fitness programs in the hope of reducing health benefit costs and increasing productivity (Howe, 1983). According to R. Keith Fogle, president of both the

Association of Fitness Directors in Business and Prudential Life Insurance, companies support fitness programs because they "understandably want their employees to: perform at high levels of productivity, remain on the job, have a low level of absenteeism, and generate a low number of health care claims" (Driver & Ratliff, 1982). Also, the President's Council on Pnysical Fitness and Sports (PCPFS) has reported:

> Habitual inactivity is thought to contribute to hypertension, chronic fatigue and resulting physical inefficiency, premature aging, the poor musculature and lack of flexibility which are the major causes of lower back pain and injury, mental tension, coronary heart disease and obesity. The PCPFS estimates that premature deaths cost American industry more than $25 billion every year, as well as 132 million workdays of lost production. Heart disease alone causes 52 million lost workdays...Over a million American workers call in sick on any given day, with the result that more than 330-million work-days are lost every year because of health-related causes (PCPFS, undated, pp. 2 & 3).

Moreover, "backache accounts for 93 million days of lost work, and costs U.S. industry more than $9 billion/year in lost productivity, disability payments, and lawsuits" (Oliver, 1982, p. 5).

The federal government appears to agree that health and economic benefits accrue from physical fitness and exercise. The Department of Health and Human Services (DHHS) has established national objectives to increase the public's awareness of and participation in regular physical fitness and exercise activities. One of the priority objectives is to increase the proportion of adults (aged 18 to 65) participating in vigorous physical exercise to greater than 60 percent by 1990. (It was estimated only 35 percent exercised regularly in 1978.) But DHHS recognizes that the health and economic benefits of exercise have not been fully assessed and that cooperative efforts in the public and private sectors are needed to investigate these potential benefits of exercise. Thus, DHHS is also sponsoring research studies to evaluate the effects of participation in programs of physical fitness on job performance and health care costs, as well as the interrelationship between exercise and other health behaviors. As another objective, DHHS has specified the need to develop a literature review on the health and economic benefits of participating in physical fitness/health promotion programs (PHS, 1983).

Scope of Study

This study is concerned with the relationship between physical fitness and its suggested benefits from the organizational, rather than individual, perspective. There is an ongoing argument over the best way to measure physical fitness (LaPorte, Kuller, Kupfer, McPartland, Matthews, & Caspersen, 1979); it depends on whether the definition of physical fitness includes strength, flexibility, endurance, leanness or health. The primary focus in this study will be on aerobic fitness and exercise, since this is what the USAF advocates. Aerobic or endurance exercise refers to repetitive isorhythmic activities involving major muscle groups (e.g., legs) in which energy is derived from metabolic processes using a constant flow of oxygen (Cooper, 1982). Some examples of aerobic exercises are cycling, swimming, jogging and brisk walking. For cardiovascular benefit, these activities should occur at a minimum intensity of 60-65 percent of maximum heart rate, for a duration of 15-30 minutes or more, and at a minimum frequency of three times per week (ACSM, 1978, 1980).

For the purpose of this study, it seems prudent to expand the scope to consider fitness in the broader context of physical activity. It is possible that organizations may gain some of the psychological benefits of personnel exercising regularly without achieving fitness, e.g., more positive attitudes toward self and work. Thus, the term *physical activity* will be used to encompass both aerobic fitness and exercise. This will allow consideration of the impact of varying levels of exercise that do not result in fitness by any of the scientific definitions.

The assumed benefits of physical fitness of most interest to the USAF are the organizational gains mentioned in the basic premise for its fitness program: reduced fatigue, increased energy and productivity, fewer heart problems and weight control. The relationship of these potential benefits to fitness are based on certain assumptions. In particular, it is assumed that employees who exercise will become healthier and more physically fit. They may gain side benefits: less smoking, less obesity, less harmful stress, better nutritional habits and better sleeping. These employees may also participate more in work, i.e., less absenteeism, fewer accidents (injuries, disabilities, deaths, downtime and damaged equipment), better attitude and morale, and improved self-confidence and self-image. Thus, employees may produce more through greater strength, endurance, amount of time working and better alertness. Overall, organizational effectiveness would improve through greater individual productivity and reduced health care costs (Kondrasuk, 1980 ; Pyle, 1979). The potential organizational benefits of exercise will be examined under the heading of *productivity*.

Purpose of Study

The purpose of this study is to review available research to examine the relationship between physical activity and productivity. Further, original research will be performed through cross-sectional analyses of existing survey data on physical activity and selected measures of productivity in sample national populations matched to USAF demographic characteristics. These statistical analyses should provide insights into relationships between level of physical activity, as measured by self-reported assessments, and level of productivity, as measured by self-reported number of lost workdays for illness or injury, days of hospitalization, days ill or injured in bed and number of doctor visits. The results of this study should contribute to a better understanding of the relationship between physical activity and productivity.

Methodology

Three specific objectives need to be accomplished to fulfill the purpose of this study. First, research on the influence of physical activity upon productivity will be reviewed and analyzed. Second, research on the reliability and validity of self-reported assessments as a measure of physical activity will be reviewed. Third, analyses will be performed on survey data of national samples matched to USAF demographic characteristics to determine the impact of physical activity on the selected measures of productivity.

Limitations and Assumptions

This study - similar to others in this field - is particularly sensitive to the way productivity is defined and measured. Productivity is obviously difficult to measure, whether among military personnel, civil servants or workers in business and industry. It is a product of both individual traits (intelligence, skill, experience, motivation, health, etc.) and situational variables (training, leadership, the work environment, group espirit, etc.). In the civilian sector, some estimate of the productivity of the workforce can be inferred from the quality of the product. In the armed forces, where the ultimate product is victory in war, it is impossible short of an actual war, to measure the real and relevant productivity of military manpower (Korb, 1982).

Notwithstanding this problem of measurement, the DOD has directed each of its organizations to set goals for improving productivity. The DOD definition of productivity includes two components: (1) effectiveness - accomplish the right things, in the right quantities, at the right time; and (2) efficiency - accomplish the right things with the lowest possible expenditure of resources (DODI - 5010.34, 1975). The Air Force Productivity Enhancement Program (AFR 25-3, 1982) incorporates both of these components in defining productivity. These definitions imply the need for multiple measures of both effectiveness and efficiency, which taken together comprise a more reasonable measure of overall productivity. A variety of measures obviously would be necessary to cover the multiple goals and missions in a large organization like the USAF. Only a few of these productivity measures, though, probably would apply to all activities within an organization (Tuttle, 1981).

Based on a survey of Chief Executive Officers and Industrial Relations Officers (Katzell, Yankelovitch, Fein, Ornati, & Nash, 1975), it appears most managers in business and industry take a broad view in defining productivity. Quality as well as quantity would be included by 95 percent of these managers in their definition; effectiveness and efficiency by 88 percent; disruptions, "shrinkage," sabotage and other troubles by 73 percent; absenteeism and turnover by 70 percent; customer or client satisfaction by 64 percent; and employee loyalty, morale, or job satisfaction by 55 percent. The lack of universal agreement on appropriate areas for productivity measurement is evident from this survey. Nonetheless, there appears to be substantial agreement that certain measures reflect on key aspects of an organization's overall productivity. It is assumed the USAF leadership would also find certain of these measures, including absenteeism, turnover (retention), job satisfaction and morale, to be valid, though selective, measures of productivity.

It is beyond the scope of this study to design criteria and instruments for the measurement of physical activity, physical fitness or productivity.

CHAPTER TWO

PHYSICAL ACTIVITY AND PRODUCTIVITY: A LITERATURE REVIEW

Introduction

Perhaps the most significant problem in establishing a link between physical activity and productivity has been a "lack of understanding of the multiple influences on productivity and a clear concept or model on how it might be influenced by exercise/fitness" (Howard and Mikalachki, 1979, p. 192). Several investigators (Driver et al., 1982; Howard et al., 1979; Pyle, 1979) have developed either models or concepts to show the possible relationships between exercise and productivity in an occupational setting. The model of Howard and Mikalachki appears to be the most comprehensive, incorporating the essential features of the other models. A review of this model will serve to clarify the hypothesized relationship between physical activity and productivity. It will also set the framework for a review of the literature.

Howard and Mikalachki's model has three general pathways (Figure 1) linking exercise/fitness and productivity. The first pathway leads to productivity through more energy and less fatigue. The second pathway leads to productivity through positive changes in attitudes and feelings towards self and work. The third pathway leads from improved fitness to productivity through better health, or the lack of illness, and its positive effect on turnover and attendance. Available research will be reviewed in the context of each of these three pathways.

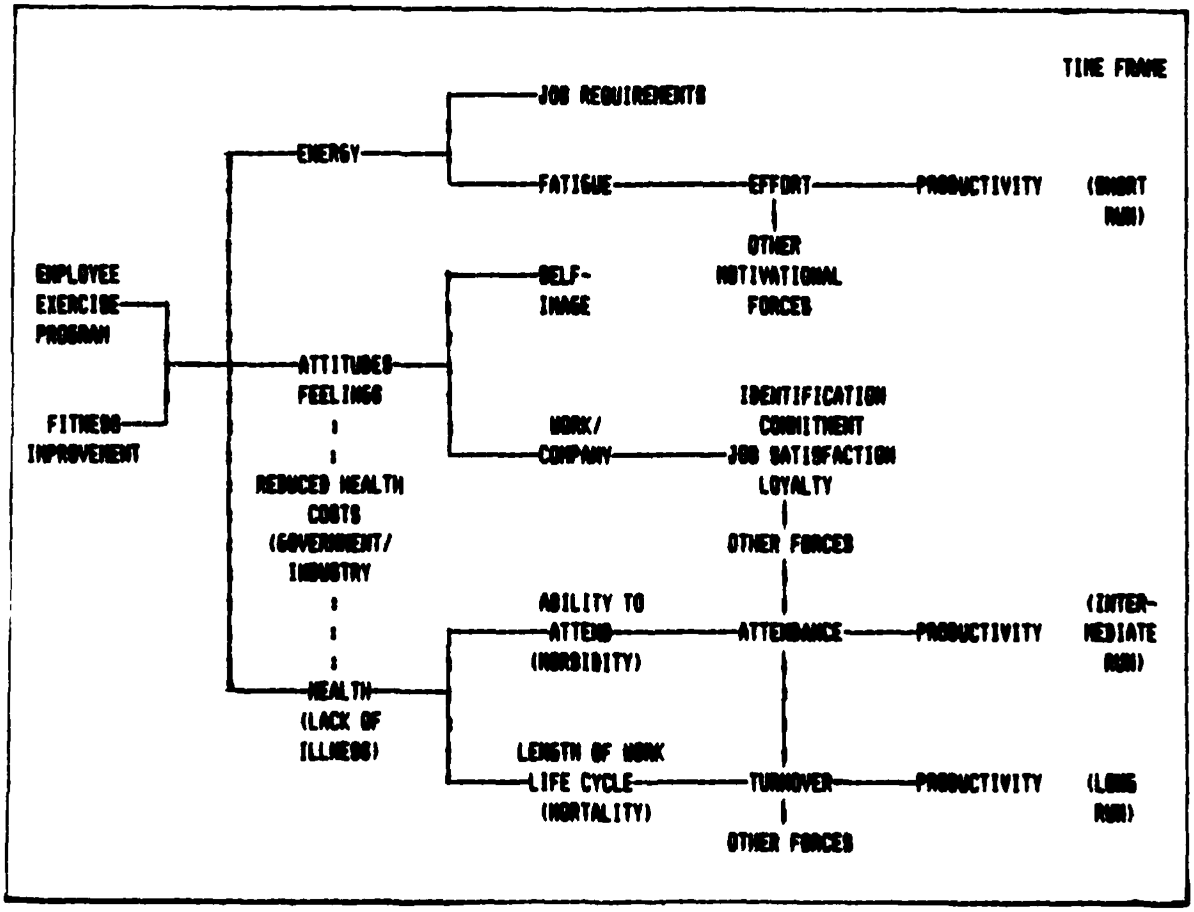


Figure 1. Exercise and Productivity Model

Energy

The first path (Figure 2) of Howard and Mikalachki's model leads from physical activity to productivity through increased energy and reduced fatigue. They suggest: "the nature of the job and the relationship between physical and mental fatigue are two important factors bearing on productivity. Fatigue can directly influence the effort put into a job" (p. 194). We will examine available research with these relationships in mind.

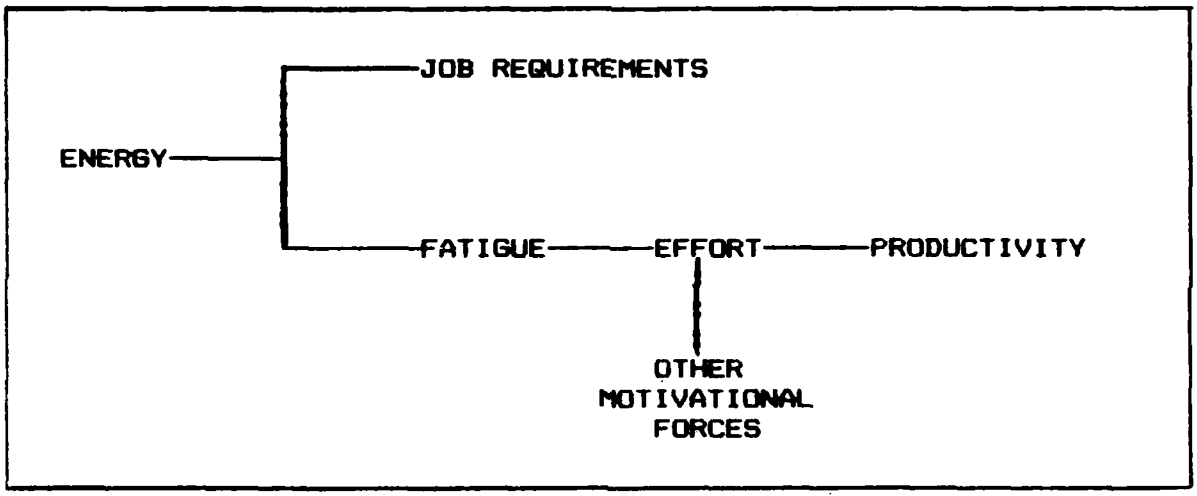


Figure 2. Energy and Productivity Path

Energy and Job Requirements

Jobs differ in their energy demands, both in amount and duration. For instance, certain types of manual labor may require high energy continuously, but in others the demand may be only periodic or even sporadic. In general, the impact of physical fatigue on effort and productivity depends upon the worker's ability to expend energy, or physical work capacity. VO_{2max}, or the volume of maximum oxygen consumption in a given period of time, is a common measure of physical work capacity, as well as physical fitness (Astrand & Rodahl, 1977).

Several investigators have confirmed that physical activity does, indeed, affect VO_{2max} by studying the effects of cessation of physical activity (Saltin, Blomqvist, Mitchell, Johnson, Wildenthal & Chapman, 1968 ; Stremel, Convertion, Bernauer & Greenleaf, 1976). Their research found that bed rest of as little as three weeks had adverse effects on physical work capacity in terms of VO_{2max} and heart rate. Further, Bennett and Bondi (1981), in a study on naval submariners, found that physical fitness measures (VO_{2max} and heart rate) decreased during submarine patrols, most likely because of physical inactivity.

A number of investigators (Shephard, 1974; Banister, 1978; Haskell & Blair, 1982) have also observed that the effects of physical fatigue tend to decrease as physical work capacity increases. In his review of fitness and fatigue research, Shephard concluded that:

> An increase of habitual activity and resultant gains of aerobic power, muscle strength, improved posture, changes in muscular fuel, improvements of thermo-regulation, and alterations of pain threshold, mood, and arousal can all reduce the liability to fatigue (p. 807).

Shephard further reported that under normal work conditions, most people prefer to carry out self-paced tasks at 40 percent or less of their physical work capacity. Similarly, Haskell et al.

(p. 257) observed that: "People can work for extended periods (eight hours or more) at no more than 20 to 25 percent" of their physical work capacity. Banister reported that the perception of difficulty in a standard work test decreased as personal fitness levels increased. These findings suggest that the effects of fatigue on productivity are likely to show up when individuals use more than a moderate amount of their physical work capacity in sustained work.

Studies on manual laborers have shown that improved physical work capacity is associated with both increased work capacity and productivity. Davies (1973), in his study of 78 East African sugarcane workers, found that high producers had a 20 percent advantage in both VO_{2max} and daily work output over low producers. Though VO_{2max} was positively correlated ($r=0.46$) with daily output, there was no correlation with annual output. Still, the natural decrease in VO_{2max} of older workers was reflected in reduced output, giving a better indication of the long-term relationship between VO_{2max} and work output. The results also showed that: "There was a small but significant ($r=-0.32$, $p<0.001$) negative association of VO_{2max} with the number of days that an individual voluntarily absented himself from the cane fields" (p. 146).

Spurr, Barac-Nieto and Maksud (1977 a&b), in separate studies on 46 sugarcane cutters and 28 loaders in Colombia, also demonstrated a positive relationship between productivity and physical fitness. For sugarcane cutters, productivity was positively related to physical work capacity (VO_{2max}), height and body fat ($r=0.685$; $p<0.001$). For sugarcane loaders who do not work continuously like the cutters, the correlation between VO_{2max} and work output was not as strong ($r=0.354$) and only approached statistical significance ($p=0.073$). However, there was a significant negative correlation ($r=0.434$, $p=0.02$) between output and resting heart rate; thus, "productivity in the sugarcane loaders would seem to be related to physical fitness" (p.1745).

The findings of scientists from the USAF School of Aerospace Medicine are of more immediate concern. These investigators have studied rapid runway repairmen during readiness exercises to determine the combined effects of heat-related stress and fatigue on performance. Van Orman & Langford (1982, p. 17) reported:

> Only those personnel who were found to be above average in aerobic capacity (physical fitness) and at least partially heat acclimated, as indicated by recent regular exposure to heat and exercise, were able to complete their task without incident. It is now clear that an individual's chances for survival in this kind of environment are directly related to his physical fitness.

Pravosudov (1978) offered further support for the association between physical work capacity and productivity in his review of Russian research. Several investigations have shown that people with higher working capacity also had higher work output, usually 2-5 percent and sometimes 10-15 percent greater than those with lower work capacity (Akimov, Baka, Kukushin & Zholdak cited in Pravosudov, 1978). Manual labor reportedly produced the strongest associations between physical fitness and productivity. Pravosudov also noted that cessation of regular physical exercise, or even significant reductions, can have adverse effects on physical work capacity.

The literature in this area is reasonably conclusive. It supports the premise that physical activity is associated with increased work capacity or physical fitness. It also supports the premise that physical activity is associated with productivity, especially in jobs requiring the continuous expenditure of high amounts of energy (for example, many types of manual labor). In jobs requiring high energy in only periodic (airfield cargo handlers) or sporadic (policemen) bursts, the association between fitness and productivity, though not as distinct, is still evident. Most sedentary jobs do not appear to require significant amounts of energy. Thus, fitness would probably not translate directly into increased productivity. Howard et al. (1979, p. 195) believe that:

> Most jobs and occupations require only a very minimal fitness level which almost all incumbents would meet. Consequently, in terms of physical fatigue influencing effort, there will be almost no relationship. The variance in productivity which might be explained on the basis of physical fatigue would be small and almost negligible. In such cases, other factors which influence effort put in will be so dominant as to make the effects of fitness undetectable.

Of course, Howard et al. are referring to civilian jobs. The energy demand of many military jobs may, and probably will, be significantly greater during wartime than peacetime. Thus, it would be possible for civil engineer personnel to fix runways during peacetime, but as rapid runway repairmen, not be able to accomplish their duties during wartime. This consideration underscores the need for fitness standards based on wartime requirements for each military skill.

Energy and Fatigue

The other avenue in the first path of Howard and Mikalachki's model considers the effect of physical fitness on mental fatigue and effort and, in turn, productivity. Shephard (1974) notes that mental fatigue can be distinguished from physical fatigue because the worker wants a change instead of rest. Fatigue is only one of many factors that can affect effort; reward, punishment, and pride, for example, can also influence effort. The amount of effort put into work, though, is usually directly related to productivity. We will review studies dealing with this relationship next.

Studies of mental performance indicate that physical activity may reduce the effects of mental, as well as physical, fatigue. Elsayed, Ismail, and Young (1980) studied intellectual differences among high-fit, young; high-fit, old; low-fit, young; and low-fit, old groups. Each group was given two intelligence tests before and after a physical fitness program consisting of jogging, calisthenics, and recreational activities. The high-fit group, regardless of age, had a significantly ($p<0.05$) higher score than the low-fit group on intelligence tests. The high-fit group also scored significantly higher on intelligence tests at the post-test than at the pre-test. Powell and Pohdorf (1971) replicated several of these results in their research. Further, short term memory improved with physical activity in another study (Davey, 1973).

Suominen-Troyer (1982) hypothesized that increased physical fitness results in improved decision making capabilities. Male and female subjects were divided into an experimental group of 27 and a control group of 13. They were tested before and after a six-month physical fitness program. Results indicated that physically fit "subjects had 60% fewer errors than the control group in formulating strategies in complex decision making tasks" (p. 4102B). The effects of physical fitness on decision making were the same for both sexes. Further, Podalko (cited in Pravosudov, 1978, p. 263) showed that: "There was a close relationship between the degree of physical activity of the scientists and the state of their health as well as their working capacity and their creative activity."

Bennett et al. (1981) reviewed a number of studies where mental performance was tested before, during and after physical exercise. Several studies addressed the immediate effects of physical activity. Duffy (cited in Bennett et al., 1981) tested motor tasks and cognitive functions during and after exercise and found that performance increased to a point then decreased. Gutin (cited in Bennett et al., 1981) found performance on a symbol substitution task improved following mild exercise, but decreased following an exhaustive treadmill run.

Bennett noted other studies of the longer range effects of fitness and mental test performance. Gutin found only a moderate relationship existed between the effects of fitness and mental task performance, following physical and mental stress. Sjoberg (cited in Bennett et al., 1981) compared fitness levels and mental performance in two different fitness groups and reported significantly better mental performance in the fit group. Weingarten (cited in Bennett et al., 1981), in a review of studies comparing physically fit and unfit subjects, observed a clear trend in mental performance. Fit subjects consistently outperformed the unfit in solving complex cognitive problems under stress. However, there was no significant difference for less difficult problems under low stress. Folkins and Sime (1981) also found a similar trend in their review which will be more fully discussed in the next section.

The literature indicates some association between fitness, mental fatigue and productivity. However, there is little research available showing this association in an occupational setting. Shephard (1974) cautions that mental fatigue is difficult to discuss in quantitative terms. In modern jobs, most people simply do not have to work at the level of productivity where mental or physical fatigue develops. Howard et al. (1979, p. 195) assume: "Occupations characterized by a high risk of mental fatigue are the ones most likely to demonstrate a relationship of exercise/fitness to productivity." Otherwise, little relationship is likely. Available research seems to indicate their assumption is correct.

Further, we did not find any research that attempted to distinguish the impact of fatigue on effort from other likely influences. Elsayed et al. (1980) agree with Howard et al. that improvements in mental performance could result from other factors which influence effort. They assert: "Participating in exercise programs may make individuals feel better about themselves, thereby enhancing feelings of self-worth and decreasing psychological distress" (p. 386). Overall, the influence of mental fatigue on effort in most jobs is masked by the impact of other factors affecting effort (Howard et al., 1979). We will consider some of these other factors in the next pathway.

Attitudes and Feelings

The second pathway (Figure 3) of Howard and Mikalachki's model deals with physical activity and its effects on productivity through changes in attitudes and feelings. They see two possible outcomes in this area. First, physical activity may lead to a more positive self-image. Since a positive self-image is related to health and longevity, it may lead to increased productivity in the long run. The second possibility is that physical activity may produce a change in feelings, which may foster a more positive attitude toward both work and the organization. The literature will be discussed in this light.

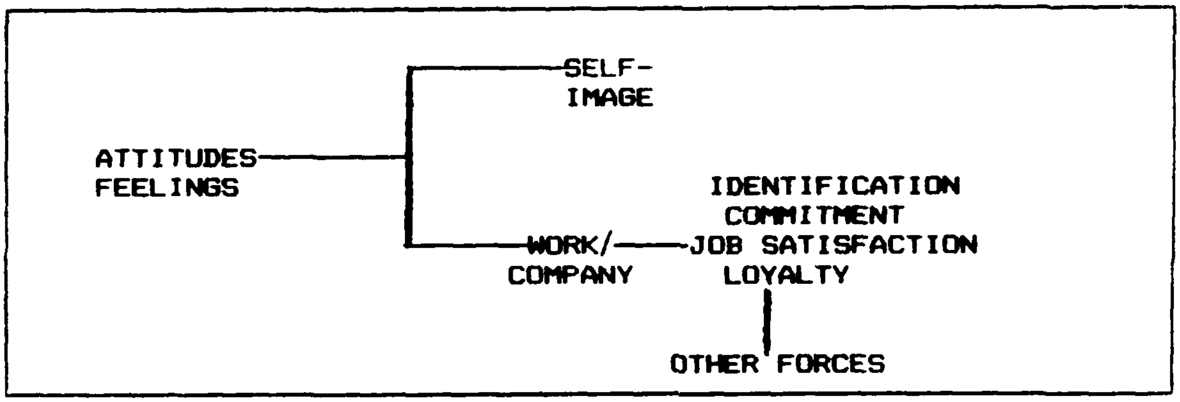


Figure 3. Attitudes/Feelings and Productivity Path

<u>Attitudes/Feelings and Self-Image</u>

Physical activity does appear to produce increases in self-concept or self-image. Folkins and Sime (1981) studied the relationship between physical fitness training and psychological traits. Their review of the literature suggests:

> Physical fitness training leads to improved mood, self-concept, and work behavior; the evidence is less clear as to its effects on cognitive functioning, although it does appear to bolster cognitive performance during and after stress. Except for self-concept, personality traits are not affected by improvements in physical fitness (p. 373).

Tables 1, 2 and 3, prepared by Folkins and Sime, provide support for this conclusion by summarizing the pertinent research studies. These tables separately show the effect of physical fitness training on cognition and perception, affect (emotion),

TABLE 1
EFFECTS OF PHYSICAL FITNESS TRAINING ON COGNITION AND PERCEPTION

STUDY	PRIMARY FOCUS	SUBJECTS	DEMONSTRATED FITNESS EFFECTS?	PSYCHOLOGICAL MEASURES AND TASKS	OUTCOME
ARNHEIM & SINCLAIR (1974)A	PERSONALITY, SELF-AWARENESS, VISUAL PERCEPT	ELEMENTARY AGE CHILDREN	? (MOTOR SKILLS IMPROVED)	CALIFORNIA TEST OF PERSONALITY, FROSTIG MOVEMENT SKILLS TEST DRAW-A-PERSON TEST, READING EYE CAMERA III	IMPROVED
BARRY ET AL. (1966)A	COGNITION	GERIATRIC	YES	RAVEN'S PROGRESSIVE MATRICES, SHORT-TERM RETENTION, SIMPLE ADDITION, AMBIGUOUS STIMULI	NO CHANGE
FRETZ ET AL. (1969)A	COGNITION, PERCEPTUAL-MOTOR	CHILDREN	NO (8-WK PHYSICAL DEVELOPMENT PROGRAM)	WISC, FROSTIG, BENDER-GESTALT TEST	IMPROVED
GUTIN (1966)A	COGNITION	COLLEGE MALES	NO (12-WKS, 2X WK FITNESS TRAINING)	EMPLOYEE APTITUDE SURVEY	NO CHANGE
GUTIN & DIGENNARO (1968)A	COGNITION	STUDENTS IN A "CONDITIONING" CLASS	NOT FITNESS ORIENTED (8 WKS, STEP-UPS)	ARITHMETIC TASKS AFTER STEP-UP EXERCISE (POSTTEST ONLY)	SOME IMPROVED
ISMAIL (1967)A	COGNITION	FIFTH AND SIXTH GRADERS	NO (1 YR. 30 MIN PE, 3 X WK)	OTIS IQ, STANFORD ACADEMIC ACHIEVEMENT	NO CHANGE IMPROVED
JOHNSON & FRETZ (1967)C	PERCEPTUAL-MOTOR	CHILDREN	NO (6-WK PHYSICAL DEVELOPMENT PROGRAM)	TACHISTOSCOPE MEASURE, MIRROR DRAWING TASK	IMPROVED
O'CONNER (1969)A	PERCEPTION, COGNITION	FIRST GRADERS	?(KEPHART PROGRAM, MOTOR SKILLS IMPROVED)	PERCEPTUAL FORMS TEST, METROPOLITAN READINESS AND ACHIEVEMENT TEST	NO CHANGE
POWELL (1974)B	COGNITION	GERIATRIC MENTAL PATIENTS	NO (12 WKS, 1 HR EXERCISE, 5 X WK)	WECHSLER MEMORY SCALE RAVEN'S PROGRESSIVE MATRICES, MEMORY-FOR-DESIGNS	IMPROVED
	BEHAVIOR			SEVERAL GERIATRIC BEHAVIOR SCALES	NO CHANGE
STAMFORD ET AL. (1974)B	COGNITION, BEHAVIOR	GERIATRIC MENTAL PATIENTS	YES D	DRAW-A-PERSON, WAIS, BEHAVIOR SCALES	SOME IMPROVED
WEINGARTEN (1973)A	COGNITION	HIGHWAY PATROL TRAINEES	YES D	RAVEN'S PROGRESSIVE MATRICES	IMPROVED
YOUNG (1979)C	COGNITION	MALE AND FEMALE ADULTS	YES D	WAIS, TRAIL-MAKING TEST, CROSSING-OFF TEST, WECHSLER MEMORY SCALE SUBTESTS	IMPROVED

NOTES: WISC = WECHSLER INTELLIGENCE SCALE FOR CHILDREN; WAIS = WECHSLER ADULT INTELLIGENCE SCALE; WK(S) = WEEK(S); YR = YEAR; MIN = MINUTES; PE = PHYSICAL EDUCATION; HR = HOUR; A = APPROXIMATES NONEQUIVALENT CONTROL GROUP QUASI-EXPERIMENTAL DESIGN, BUT RANDOM ASSIGNMENT ASSUMPTION IS NOT MET; ISMAIL (1967) AND WEINGARTEN (1973) USED MATCHING PROCEDURES; B = EXPERIMENTAL DESIGN; C = PREEXPERIMENTAL DESIGN; D = CARDIOVASCULAR FITNESS.

TABLE 2
EFFECTS OF PHYSICAL FITNESS TRAINING ON AFFECT

STUDY	PRIMARY FOCUS	SUBJECTS	DEMONSTRATED FITNESS EFFECTS?	PSYCHOLOGICAL MEASURES AND TASKS	OUTCOME
R. S. BROWN ET AL. (1978, PHASE 1)A	DEPRESSION	HIGH SCHOOL & COLLEGE ATHLETES	NO (10 WKS, JOGGING)	ZUNG SELF-RATING DEPRESSION SCALE	IMPROVED
DEVRIES (1968)A	TENSION	MIDDLE-AGED MALES	YES	ELECTROMYOGRAM	IMPROVED
FOLKINS (1976)A	MOODS	MIDDLE-AGED MALES AT RISK OF CHD	YES D	MAACL	IMPROVED (ANXIETY)
FOLKINS ET AL. (1972)A	MOODS, PERSONALITY, WORK, SLEEP	COLLEGE MALES AND FEMALES	YES D	MAACL, RATING SCALES	IMPROVED (FEMALES)
D. S. HANSON (1979)B	ANXIETY	4-YEAR-OLDS	NO (10 WKS, 30 MIN MOVEMENT TRAINING, 5 X WK)	HOLTZMAN INKBLOT TEST, TEACHER RATING	IMPROVED
KARBE (1966)C	ANXIETY	COLLEGE FEMALES	NO (15 WKS, 40 MIN SWIMMING, 2 X WK)	IPAT ANXIETY SCALE SWIMMING ANXIETY & FEAR CHECK LIST	IMPROVED
KOWAL ET AL. (1978)A	MOODS, SELF-CONCEPT, PERSONALITY	MALE AND FEMALE RECRUITS	YES D (MALES ONLY)	SPIELBERGER STAI, PROFILE OF MOOD STATES, EYSENCK PERSONALITY INVENTORY	MOOD IMPROVED (MALES)
LYNCH ET AL. A	MOODS	MIDDLE-AGED MALES	NO (UNIVERSITY EXERCISE CLASS, JOGGING)	MAACL	IMPROVED
MCPHERSON ET AL. (1967)	MOODS	POSTINFARCT & NORMAL ADULT MALES	NO (24 WKS, GRADUATED EXERCISE, 2 X WK)	SEMANTIC DIFFERENTIALS (MOODS)	IMPROVED
MORGAN ET AL. (1970)	DEPRESSION	ADULT MALES	NO	DEPRESSION SCALE	NO CHANGE
MORRIS AND HUSMAN (1979)A	WELL-BEING	COLLEGE STUDENTS	YES	PFLAUM LIFE QUALITY INVENTORY	IMPROVED
POPEJOY (1968)C	ANXIETY	ADULT FEMALES	NO (20 WKS, 4 X WK FITNESS TRAINING)	IPAT ANXIETY SCALE, NEUROTICISM SCALE	IMPROVED
TREADWAY C	MOODS	OLDER ADULTS	NO	STAI, DEPRESSION SCALE, MOOD STATE INVENTORY	IMPROVED
YOUNG (1979)C	WELL-BEING, ANXIETY	MALE AND FEMALE ADULTS	YES D	LIFE SATISFACTION & HEALTH RATING SCALES, MAACL	IMPROVED

NOTES: MAACL = MULTIPLE AFFECT ADJECTIVE CHECK LIST; IPAT = INSTITUTE FOR PERSONALITY AND ABILITY TESTING; STAI = SPIELBERGER STATE-TRAIT ANXIETY INVENTORY; CHD = CORONARY HEART DISEASE; WK(S) = WEEK(S); MIN = MINUTES; A = APPROXIMATES NONEQUIVALENT CONTROL GROUP QUASI-EXPERIMENTAL DESIGN, BUT RANDOM ASSIGNMENT ASSUMPTION IS NOT MET; MCPHERSON ET AL. (1967) USED MATCHING PROCEDURES; B = EXPERIMENTAL DESIGN; C = PREEXPERIMENTAL DESIGN; D = CARDIOVASCULAR FITNESS.

TABLE 3
EFFECTS OF PHYSICAL FITNESS TRAINING ON PERSONALITY AND SELF-CONCEPT

STUDY	PRIMARY FOCUS	SUBJECTS	DEMONSTRATED FITNESS EFFECTS?	PSYCHOLOGICAL MEASURES AND TASKS	OUTCOME
PERSONALITY					
BUCCOLA & STONE (1975)A	PERSONALITY	OLDER MALES	YES D	16 PF	SOME IMPROVED
DUKE ET AL. (1977)A	LOCUS OF CONTROL	CHILDREN	YES D	CHILDREN'S INTERNAL-EXTERNAL CONTROL SCALE	IMPROVED
FOLKINS ET AL. (1972)B	PERSONALITY(PRESENT ADJUSTMENT)	COLLEGE MALES & FEMALES	YES D	ACL (SELF-CONFIDENCE & PERSONAL ADJUSTMENT)	IMPROVED (FEMALES)
ISMAIL & YOUNG (1973)A	PERSONALITY	MIDDLE-AGED MALES	YES D	16 PF	SOME IMPROVED
ISMAIL & YOUNG (1977)A	PERSONALITY	MIDDLE-AGED MALES	YES D	16 PF, EYSENCK PERSONALITY INVENTORY, MAACL (ANXIETY)	NO CHANGE
KOWAL ET AL. (1978)B	MOODS, SELF-CONCEPT, PERSONALITY	MALE AND FEMALE RECRUITS	YES D (MALES ONLY)	STAI,PROFILE OF MOOD STATES, EYSENCK PERSONALITY INVENTORY	MOOD IMPROVED (MALES)
MAYO (1975)B	PERSONALITY	SEVENTH & EIGHTH GRADE FEMALES	YES D	CATTELL JUNIOR-SENIOR HIGH SCHOOL QUESTIONNAIRE	NO CHANGE
NAUGHTON ET AL. (1968)B	CLINICAL SCALES	POSTINFARCT MALES	YES D	MMPI	NO CHANGE
TILLMAN (1965)B	PERSONALITY	HIGH SCHOOL MALES	YES	16 PF,KUDER PREFERENCE RECORD	NO CHANGE
WERNER & GOTTHEIL (1966)A	PERSONALITY	COLLEGE MALES	NO(4-YR ATHLETIC PROG.)	16 PF	NO CHANGE
YOUNG & ISMAIL (1976)A	PERSONALITY	MIDDLE-AGED MALES	YES D	16 PF, EYSENCK PERSONALITY INVENTORY, MAACL (ANXIETY)	SOME IMPROVED
SELF-CONCEPT					
BRUYA (1977)C	SELF-CONCEPT	FOURTH GRADERS	NO (4 WKS, 30 MIN SESSION,2X WK)	PIERS- HARRIS CHILDREN'S SELF-CONCEPT SCALE	NO CHANGE
COLLINGWOOD (1972)B	BODY AND SELF ATTITUDES	ADULT MALE REHABILITATION CLIENTS	YES D	BODY ATTITUDE SCALE,SEMANTIC DIFFERENTIALS,BILLS INDEX OF ADJUSTMENT & VALUES	IMPROVED
COLLINGWOOD & WILLETT (1971)A	BODY AND SELF ATTITUDES	OBESE MALE TEENAGERS	YES D	SAME AS ABOVE	IMPROVED
HANSON & NEDDO(1974)	SELF-CONCEPT	ADULT FEMALES	YES D	TENNESSEE SELF-CONCEPT SCALE	IMPROVED
HILYER & MITCHELL (1979)E	SELF-CONCEPT	COLLEGE MALES & FEMALES	YES D	TENNESSEE SELF-CONCEPT SCALE	IMPROVED
MARTINEK ET AL. (1978)E	SELF-CONCEPT	ELEMENTARY AGE CHILDREN	YES	MARTINEK-ZAICHKOWSKY SELF-CONCEPT SCALE FOR CHILDREN	IMPROVED
MAUSER & REYNOLDS (1977)A	SELF-CONCEPT	ELEMENTARY AGE CHILDREN	YES	SELF-CONCEPT SCALE FOR CHILDREN	NO CHANGE
MCGOWAN ET AL. (1974)E	SELF-CONCEPT	SEVENTH-GRADE MALES	YES D	TENNESSEE SELF-CONCEPT SCALE	IMPROVED

NOTES: 16 PF = CATTELL'S SIXTEEN PERSONALITY FACTOR QUESTIONNAIRE; ACL = ADJECTIVE CHECK LIST; MAACL = MULTIPLE AFFECT ADJECTIVE CHECK LIST; STAI = STATE-TRAIT ANXIETY INVENTORY; MMPI = MINNESOTA MULTIPHASIC PERSONALITY INVENTORY; YR = YEAR; WK(S) = WEEK(S); MIN = MINUTE; A = PREEXPERIMENTAL DESIGN; B = APPROXIMATES NONEQUIVALENT CONTROL GROUP QUASI-EXPERIMENTAL DESIGN, BUT RANDOM ASSIGNMENT ASSUMPTION IS NOT MET; MAYO (1975) AND COLLINGWOOD (1972) USED MATCHING PROCEDURES; C = QUASI-EXPERIMENTAL DESIGN (SEPARATE SAMPLE PRETEST-POSTTEST); D = CARDIOVASCULAR FITNESS; E = EXPERIMENTAL DESIGN.

personality and self concept.

In addition, other investigators have found that physical activity influences self-image. In the Perrier Study, pollster Louis Harris (1978) polled 1,510 people over 17 years of age. He found 80 percent of all physically active respondents reported feeling better as a result of exercise. Highly active participants also reported a more positive frame of mind than those in the low-active group. In particular, those in the high-active group felt less tired, more disciplined, more relaxed, and more productive in work. They also said they sleep better, look better, have improved concentration, are better able to cope, are more assertive, think more creatively, believe that they will live longer and have a better self-image. Further, the low-active group reported significantly more positive attitudes than the "non-actives."

Bowne, Hellman, Richardson, Clarke, Bransford, Russell and Goodrick (1981) in a study of the corporate fitness program of Prudential Insurance Company (Southwest Home Office) reported survey data of 66 random participants. After being in the program over one year, entrants reported feeling better physically (75.8%), mentally (66.2%), emotionally (59.1%), and felt more productive (54.7%). At Kimberly-Clark Corporation, Dedmon (1980) also found that a program of regular physical exercise significantly improves participants' subjective sense of well being and physical work capacity; an update by Dedmon and Sroczyk (1983) continues to support these findings.

The literature suggests a strong link between physical activity and a positive self-image. The literature, however, does not demonstrate that an improved self-image yields increased productivity. We agree with Howard et al. that an improved self-image probably does not by itself lead directly to productivity, at least in the short run. In the long run, the improvement in self-image may lead, through its influence on health, to productivity.

Attitudes/Feelings Toward Work

In Howard and Mikalachki's model, fitness may also lead to productivity through positive changes in attitudes and feelings toward work and the organization. These positive attitudes and feelings may produce better identification with the organization and commitment to its goals, and generate a greater sense of loyalty and job satisfaction. We will look at this relationship now.

A number of studies have correlated physical activity with positive attitudes and feelings toward work and the organization. Heinzelmann and Bagley (1970) studied sedentary men 45-59 years of age at the Universities of Minnesota, Wisconsin and Pennsylvania State. They reported: "almost 60% of the 108 program participants...indicated... that the program had a significant positive effect on their work performance" (p. 908). Participants also reported more positive attitudes toward work, increased stamina, weight reduction, and greater ability to cope with stress and tension. The NASA study (Durbeck, Heinzelmann, Schacter, Haskell, Payne, Moxley, Nemiroff, Limoncelli, Arnoldi & Fox, 1972) replicated many of these results. Of the 237 male subjects who adhered to the corporate fitness program, approximately 50% reported they could work, in their opinion, harder mentally and physically; about 49% enjoyed their jobs more and found their normal work routine less boring, while 50% felt less stress and tension.

Wilbur (1984) has reported preliminary data from the first year of a two-year study of Johnson and Johnson's health promotion program. With 1,417 subjects divided into treatment and control groups, he has found significant differences ($p=0.01$) reflecting weight reduction and improved sense of well-being, satisfaction with working conditions, satisfaction with personal relations at work, and ability to handle job strain in the treatment group. At a higher significance level ($p=0.05$), he also noted positive differences for the treatment group in smoking cessation, sick days and job self-esteem.

Blair, Pate, Howe, Blair, Rosenberg and Parker (1979) studied 504 personnel of the Liberty Corporation to examine the relationship between physical activity and job satisfaction. Previously validated questionnaires were used to gather data on job pressures, satisfaction, rewards, motivation, and social support. The results "support the hypothesis that the amount of leisure time activity is related to some measures of job satisfaction" (p. 105).

However, other investigators have not been able to confirm these findings. In a study of commercial real estate investment brokers, Edwards and Gettman (1980) randomly assigned 32 subjects to test and control groups. The test group participated in a six-month aerobics training program. Afterwards, the results of physiological tests reflected significant training effects in the test group. But, there were not any significant differences between the trained and untrained groups in job performance (measured by change in monetary amount of commissions) or job satisfaction (measured by the Job Descriptive Index). Though not statistically significant, there was a strong tendency for increased physical fitness to be reflected in increased sales commissions.

Cox, Shephard, and Corey (1981) could not confirm that physical activity increases job satisfaction, either. In a study of 1,125 personnel of two Canadian Assurance Companies, they found that attitudes toward work improved, but not job satisfaction. Forty-seven percent of exercise-class participants reported that "work was more enjoyable and less routine; they also felt more alert at work and had a better rapport with supervisors and co-workers" (1981, p. 799). They also noted increased VO_{2max} and flexibility along with lower body fat in the exercise group. However, productivity was increased by three to four percent in both the treatment and control groups. In another study of these Canadian companies (Shephard, Cox & Corey, 1981, p. 359), the exercise group improved in fitness, but "self-reports and supervisor evaluations showed small and relatively similar gains of productivity, with reduction of absenteeism at both test and control companies." Shephard et al. believe the "Hawthorne" effect - a change in behavior caused by attention received from participation in an experiment - may have been responsible for the occurrence of similar productivity gains in both the test and control groups.

The literature provides ample support showing that physical activity may improve attitudes and feelings toward work and company. The literature, however, does not contain any conclusive research showing that these positive attitudes and feelings translate directly into better identification with the organization, commitment to its goals, loyalty, and job satisfaction. It is difficult to measure possible outcomes, like job satisfaction and commitment. They are subjective in nature, and it is extremely difficult to control the many factors other than physical activity that may simultaneously influence them. Even if there was a conclusive connection between physical activity and these outcomes, research has not established that these outcomes are directly related to productivity. For example, while research consistently shows that job satisfaction is inversely correlated with absenteeism (Muchinsky, 1977), it only suggests that job satisfaction leads to performance. In fact, some research indicates that *performance* leads to job satisfaction. Some investigators even question whether there is any relationship between job satisfaction and performance (Driver et al., 1982).

Finally, it is not clear whether these changes in attitudes and feelings occur through physical activity or participation in a company-sponsored fitness program or both. Many studies in industrial settings were methodologically flawed to the point that it is not possible to separate the effects of physical activity from other possible influences. The methodological problems include unvalidated self-reporting of effects, lack of control groups, non-random assignment of subjects to treatment and control groups, and inadequate consideration of confounding variables. Perhaps, participation in any company recreational program, even if it does not involve physical activity, may produce positive changes in attitudes and feelings. Both the company's concern for employee well-being reflected in this type of program and the accompanying "social" opportunities may improve employee attitudes and feelings toward work and the company. The literature does not offer for comparison any studies of the effects of a personal "program" of physical activity on attitudes and feelings toward work and the company. Therefore, conclusive research on this pathway must await clarification of the relationships between the many sequential and subjective links between fitness and productivity.

Health (Lack of Illness)

The last pathway (Figure 4) of Howard and Mikalachki's model leads from physical activity to productivity through health or the lack of illness. It seems plausible that healthier individuals live longer (decreased mortality) and have less illness (decreased morbidity) than unhealthy people. Thus, because of greater availability for work, turnover and absenteeism may be reduced and productivity increased. There are obviously many ways to measure productivity, but turnover and absenteeism remain valid measures. As Howard et al. note, if workers are not present on the job, they cannot be productive. First, we will review the literature on physical activity and mortality, then morbidity.

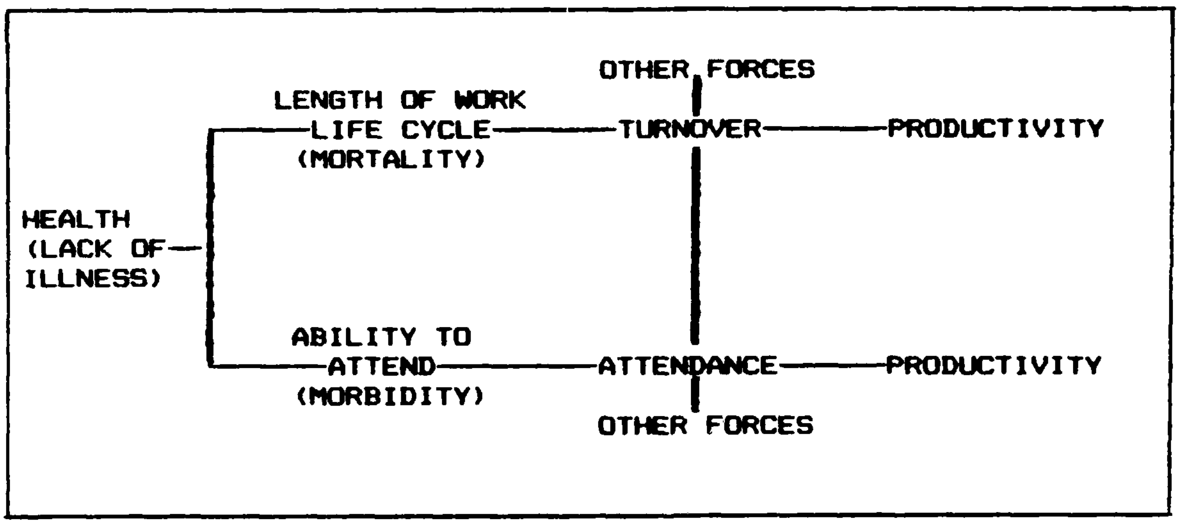


Figure 4. Health and Productivity Path

Mortality

Lifetime productivity may be assumed, in general, to be a function of the length of time an individual works. Overall individual productivity may be reduced if the work cycle is cut short by premature death or disability. Organizational productivity may also be adversely affected by increased turnover caused by premature deaths or disabilities. In this section, we will examine the influence of physical activity on heart disease since it is the leading cause of death in men aged 35 to 54 and the second leading cause for women in this age bracket (Fielding, 1979).

Physical activity does appear to protect against heart disease. Eichner (1983) reviewed the epidemiologic evidence for and against the hypothesis that exercise protects against coronary heart disease. His review concentrated on the newest and on the benchmark studies. For example, representative epidemiologic studies were made in England, Israel and the U.S. In England, double-decker bus drivers were compared with more active conductors. The more sedentary drivers had more fatal infarctions and three times as many sudden deaths as the conductors. British civil servants with similar desk jobs but different hobbies were also studied. The results indicated: "Men with vigorous pursuits had only half as many coronary attacks as their more sedentary colleagues" (p.1011). In Israeli kibbutzim, sedentary men had two to four times as much coronary disease as the nonsedentary men.

In Georgia and Iowa studies, farmers with their rigorous work have had less coronary disease than nonfarmers. In Seattle, a study has shown that "persons who engage in vigorous leisure-time exercise have a reduced risk of primary cardiac arrest" (pp. 1011-1012). In San Francisco, longshoremen with more sedentary jobs had 33 percent more fatal heart attacks than more active cargo handlers. More physically active Harvard alumni also had a lower risk of coronary disease than less active alumni. In Dallas, physical fitness was shown to be inversely correlated with body fat, cholesterol and triglyceride levels, blood glucose level and blood pressure. "Only one epidemiologic study has suggested that habitual vigorous physical activity may actually harm the heart" (p. 1014). Finnish lumberjacks, in a 10-year study, were found to have a higher coronary mortality rate than the next most active group, farmers. On the basis of these and other studies, Eichner wrote: "It seems, then, that both *exercise* and *fitness* correlate with coronary risk" (p. 1013).

Eichner also found "a large and reasonably consistent body of evidence" that exertion can cause sudden death in persons with heart disease. Again, representative studies were made in Finland, England, and the U.S. In Finland, the "sudden death rate in middle-aged men participating in community cross-country skiing events is about fourfold the rate for such men at rest" (p. 1017). In England, comparison of fatal and nonfatal infarctions showed fatal ones occurred at a significantly higher rate in those who were more active just before death. Further, the British study found that the "exertion" could be psychological stress as well as physical.

In the U.S., reports on sudden death in runners and joggers suggest that those who die when they are running die of heart disease; many already had heart disease when they began running, and some denied the warning symptoms. Two Seattle studies also show that "vigorous exercise protects against primary cardiac arrest, but if arrest occurs, it is more likely to occur during vigorous exercise" (p. 1017). Eichner concluded:

> The weight of the epidemiologic evidence supports the view that persons who exercise regularly have a lower risk of coronary heart disease...Unfortunately, regular exercise does not grant immunity to coronary atherosclerosis and cannot prevent the progression of coronary disease in some persons. In fact, exercise increases the acute risk of sudden death in persons with coronary atherosclerosis...Some observers now believe this risk is so small that asymptomatic persons without coronary risk factors can and should begin prudent, graded exercise programs on their own (p. 1020).

The meaning of the literature has been well summarized above by Eichner. It essentially supports the assertion of Howard et al. that regular physical activity can lengthen the work cycle by preventing premature death from heart disease. It remains an assumption, but a reasonable one, that a longer work cycle may yield greater lifetime productivity, both for an individual and an organization (through reduced turnover). With personnel policies designed to maintain a youthful and healthy force, the length of the work cycle may have less effect on the U.S. military services than civilian organizations. Nonetheless, all of the services have a substantial civilian force which is certainly older and probably less healthy than their military counterparts.

Morbidity

The ability to attend work is largely influenced by illness or injury. Obviously, there are many other reasons for being absent from work, for instance, car trouble, child care, jury duty. Still, U.S. workers have consistently attributed their absenteeism to illness and injury twice as often as any other reason (Hedges, 1977). In this section, we will review physical activity and its impact on illness and injury.

Physical activity can reduce the risk of injury, particularly in hazardous occupations. Cady, Bischoff, O'Connell, Thomas, and Allan (1979) correlated fitness with a variety of conditioning measurements for 1,652 firefighters. Using endurance work measures, isometric strength tests, spine flexibility measurements, diastolic blood pressure during exercise, and heart rate two minutes after bicycle exercise, they determined fitness levels of the firefighters. They found that back injuries were ten times higher and more costly for the least fit group than the most fit group. Also, the results showed a linear and inverse relationship between fitness level and back injuries: least fit, 7.1 percent injured; middle fit, 3.2 percent injured; and most fit, 0.8 percent injured.

Several studies show that physically active employees have lower absenteeism, as well as turnover. At Prudential Insurance Company, 1,300 sedentary workers were compared to 556 participants in the corporate aerobic exercise program (Bowne et al., 1981). Using a treadmill test to determine VO_{2max} , the participants were divided into fitness groups (low, fair, good, high). The exercise group averaged 3.5 disability days in a year, compared to 8.6 in the control group. The level of fitness also indicated an inverse linear relationship with average disability days: low fit, 8.6; fair fit, 4.1; good fit, 1.6; and high fit, 0. In addition, the exercise group had only 11 percent turnover, while the control group had 40 percent.

Linden (1969) also found an inverse relationship ($r=-0.47$) between VO_{2max} and the number of absences from work in a group of 51 customs officers. Most of the absences were caused by upper respiratory infections, headache, backpain, etc. Moreover, men with some leisure-time physical activity tended not to be absent. However, he could not replicate these results in studies of 56 firemen and 75 male and female office workers. Among the office workers, the data did show that the men and women with the highest VO_{2max} did not have any absences, but this trend was evident only for those with the highest level of VO_{2max}.

Cox et al. (1981) found that high adherents in the corporate fitness program had a 42 percent decrease in average monthly absenteeism compared ($p<0.01$) to a 20 percent decline in both the test and control companies. Both low and high adherents had significantly ($p<0.005$) lower turnover (1.5%) than nonparticipants or dropouts (15%).

Garson (cited in Fielding, 1982) also presented evidence of the association between fitness and absenteeism. He compared 100 participants in a fitness program at Metropolitan Life to 100 employees in a control group of nonparticipants. The results showed that: "Over two years the absenteeism rate for the exercise group decreased to 4.9 days/yr while in the control group it climbed to 7.0 days/yr" (p. 911). Bjurstrom and Alexiou (1978) obtained similar results in a study of 99 employees of the New York State Education Department. Using the employees as their own controls, they compared the amount of sick leave used during a year of participation in the department's physical fitness program with the year prior to entry. They found an average annual reduction of 4.7 hours per employee. Furthermore, "the mean sick leave hours for all program participants...(46.5) was substantially below the...hours reported for all New York state employees during this same year (73.5)" (p. 526).

Several Russian investigators have also reported the results of numerous studies in this area. For example, Smirnov (cited in Pravosudov, 1978) found sports participants consulted the doctor four times less often than others, with work loss involved in only 22.5 percent of these consultations versus 50-60 percent in non-participants. Ponomarev (cited in Pravosudov, 1978) also determined in one study that physically active workers were absent for illness and injury an average of three to five fewer days per year. Several investigators found that physically exercising for one to two years decreased the number of illnesses and absences in industrial, office and professional workers (Baka, Loktionova, Okk, Sorokina & Zholdak cited in Pravosudov, 1978). Donoghue (1977) provided additional support in his international review of the correlation between physical fitness, absenteeism and work performance.

Moreover, physical activity may be associated with the amount of non-accidental insurance claims. Over a 4-year period, Corrigan, Ismail and Young (cited in AAFDBI, 1980) compared 44 male adult subjects divided into habitually active and sedentary groups. They reported a significant difference between groups on physiological measures. While there were not any differences in frequency of claims, the average claim amount of the habitually active group was only half that of the sedentary group.

Most of these studies demonstrated a correlation between physical activity and one measure of productivity, absenteeism. Some research also suggests that physical activity reduces turnover, perhaps because of more positive attitudes toward the company, rather than death or disability in this case. The absenteeism is presumably caused by illness or injury, which appears to decrease with regular physical activity. The productivity of an organization benefits in many ways from a lower absenteeism rate: lower overtime payments, less training of temporary replacements, lower health care costs, etc. Reduced turnover rates can also lower the costs of recruitment and training. Research has not yet evaluated the positive effects of physical activity on health in terms of other measures of productivity than absenteeism and turnover.

Validity and Reliability of Survey Data

In the next chapter, we will analyze data from two national surveys. These data are based on the respondents' personal reports of their own health practices, including physical activity, and selected measures of productivity, such as, number of workdays lost for illness or injury. Before summarizing the literature reviewed in this chapter, we will review the validity and reliability of self-reported survey data.

Wilson and Elinson (1981) have questioned the validity of self-reports of health practices and health status. They are concerned about two related issues. First, how valid or accurate is reporting of health practices, such as, number of alcoholic drinks consumed in one sitting? Second, how are reports of health status and health habit variables influenced by perception of general health status? For example, are people who perceive their health as excellent as likely to report sick days as people who perceive their health as poor? Though not mentioned by Wilson et al., there is also the issue of reliability or consistency between a respondent's answer to the same question on surveys administered at different times. We will look at the literature with these issues in mind.

Investigators have found survey data on physical health to be reasonably valid. In a survey of 739 residents of Alameda County, California, in 1965, the validity of health data was investigated by comparing survey data with that in medical records. Meltzer and Hochstim (1970, p. 1085) reported that: "About half (54 percent) of the chronic conditions reported by survey appeared in the clinical records." However, they noted that: "Other types of complaint were less likely to appear in the clinical records than in the questionnaires (p. 1085)." They also found that the survey data on elderly (65 and over) respondents agreed better with the medical records than did those of younger respondents. It seems the medical records of older respondents tended to be more complete than those of younger respondents. Overall, Meltzer et al. explained:

> From the nature of the survey questions, and what we know of clinicians' priorities when they make record entries, it seems probable that the discrepancies can be attributed at least as much to the shortcomings of the medical records...as to the vagaries of patients' responses (p. 1085).

Andrews and Crandall (1975) obtained similar results when assessing the validity of perceptual or subjective measures of self-reported well-being. They found that the validity of individual questionnaire or interview items can be in the range of 0.7 to 0.8; this would account for roughly half to two-thirds of the variance. Further, composite measures of several items related to the same underlying perception would have higher validity than any of the individual items. They concluded:

> Perceptions of well-being can be measured with substantial validity...using a variety of methods, for qualitatively different aspects of life, and under conditions typically encountered in national household-interview type surveys (p. 16).

Investigators have also found that survey responses on health status variables is reliable. In two surveys of 1,530 different

Alameda residents in 1968, Hochstim and Renne (1971, p. 78) examined data on general health, illnesses, and attitudes and emotions. They found:

> Large proportions of the responses were reliable. Three out of four respondents answered 90 per cent or more of the items identically; only 2 per cent did so in as few as 70-79 per cent of the items...Reliability varied sharply with the type of question asked, being highest when objective facts were involved, lowest where mood or attitude was a strong factor.

Jette, Cummings, Brock, Phelps and Naessens (1981) also obtained similar reliability results.

In a pilot study to determine if self-perceptions and increased levels of physical fitness were correlated, Leonardson and Gargiulo (1978, p. 338) found: "a moderate but significant correlation ($p<0.05$) between actual and perceived physical performance on both pre- and post-test measures ($r=0.50$ and 0.52, respectively)." This suggests that self-reported measures of physical fitness are valid.

The literature concerning the validity and reliability of self-reported assessments of health variables, though not extensive, appears to be consistent. It indicates that self-reported data on health variables, including physical fitness, is reasonably valid and reliable. Further, survey items calling for objective answers would be expected to have greater validity and reliability than items calling for subjective answers. Nonetheless, subjective answers still appear to have substantial validity and reliability of their own.

Summary

Howard and Mikalachki's model accounts for the substantive results in the literature on physical activity and productivity, thus providing a sound theoretical basis for this review. The evidence clearly indicates that regular physical activity increases energy and reduces fatigue. Thus, in jobs inducing high mental and physical fatigue, the effects of physical activity on worker productivity are likely to be positive and apparent in the short run. Obviously, the number of such jobs in the military services would increase dramatically during wartime. However, the amount of energy required to perform most jobs - even military jobs during peacetime unless readiness requirements are taken into account - is low enough that the effects of physical activity would not be readily apparent in productivity. In these jobs, the longer term impact of physical activity on attitudes and feelings and health must be considered.

The research demonstrates a positive relationship between physical activity and attitudes and feelings, especially self-image. A positive self-image, though, seems likely to lead to productivity only through increased longevity, and thus a longer work cycle. The effects of physical activity on attitudes and feelings toward work and the organization is not clear, yet. Many studies reported employees participating in corporate fitness programs had more positive attitudes toward work and the company. But, most studies did not separate the effects of physical activity from the benefical effects engendered by participation in any company-sponsored program. Moreover, the theoretical interrelationships among physical activity, job satisfaction, loyalty, identification with the company and commitment to its goals, and productivity remain to be established and quantified.

As for health, the research consistently indicates the positive effects of physical activity on the risk of coronary heart disease and illness and injury. These positive effects, in turn, often have been reflected in reduced absenteeism and turnover rates, which are measures of certain aspects of productivity. This relationship has not been studied for its effects on other measures of productivity, however.

In sum, the literature does not conclusively show that regular physical activity leads directly to higher productivity in most occupations. It does consistently indicate, though, the positive influence of physical activity on productivity when substantial physical and mental fatigue or stress are involved and when long-term health or the lack of illness is considered.

CHAPTER THREE

PHYSICAL ACTIVITY AND USAF PRODUCTIVITY: IMPLICATIONS FROM SURVEYS OF SIMILAR POPULATIONS

INTRODUCTION

The literature review has presented research on the possible links between physical activity and productivity in an occupational setting. Howard and Mikalachki, in presenting their model (Figure 1), hypothesized that the most likely path between fitness and productivity in most occupations is through health (illness/disease). To study this assertion, the data bases of two national surveys were examined. While some of these data have been previously analyzed for generalization to the national population, we intend to match the data to USAF demographic characteristics and then analyze it. First, we will discuss the literature related to these surveys. Then, each survey will be presented with sections on the subjects, survey instrument, statistical procedures, results and discussion.

A substantial body of research shows that physical activity, health habits and health status are interrelated. Belloc and Breslow (1972) have reported the findings of a health survey of 7,000 adult residents of Alameda County, California in 1965. They found certain common health practices were associated with positive health. In particular, seven good health practices were identified: (1) sleeping an average of seven to eight hours a night, (2) controlling one's weight--weighing between 5 percent under and 19.9 percent over the desirable weight if male, or not more than 9.9 percent over if female (based on the 1960 Metropolitan Life height-weight standards), (3) exercising: often engaging in physically active sports, calisthenics, jogging, cycling, long walks, swimming or hobbies, (4) limiting alcohol consumption to less than five drinks per day, (5) never having smoked cigarettes, (6) eating breakfast almost every day, and (7) seldom, if ever eating snacks. Further, those who were physically active had distinctly better physical health than the physically inactive. Also, those who followed all of the good practices were in better health, even though older, than those who did not.

Further analyses of the Alameda data have corroborated the positive relationship between physical activity, health practices and health status. Belloc (1973, pp. 72-73) found that five years after the Alameda survey:

> The men who reported that they often engaged in active sports had the lowest mortality, just half that experienced by men who reported that they only sometimes gardened or exercised. Few women reported participation in active sports; their lowest mortality was among those who reported swimming, gardening, and other exercise, and the highest was among those who never engaged in recreational physical activity...The number of health practices showed a striking inverse relationship with mortality rates, especially for men.

Breslow and Enstrom (1980) confirmed that the relationship between health practices and mortality persisted after nine years. Wiley and Camacho (1980), also nine years after the Alameda study, found that physical exercise, as well as smoking, drinking, sleep and weight, remained significantly associated with overall health; an index of these five health practices was also associated with future health status. A number of other studies (Ciuca, 1967; Kannel, 1967 ; Palmore, 1969) also have shown that physical activity is associated with longevity.

At the direction of DHHS, the National Center for Health Statistics conducted further surveys designed to measure the distribution in the national population of health practices, their stability over time, and their relationship to morbidity and mortality. In 1977, the NCHS administered a Health Habits Supplement as part of the annual National Health Interview Survey (NHIS). It was designed "to obtain data on the prevalence of the 7 preventive health practices among the noninstitutionalized U.S. population aged 20 years and over" (NCHS, 1980, p. 1). Only basic data from this survey has been published by NCHS. Neither NCHS nor independent investigators seem to have published any analyses of the relationship between health habits and health status reflected in the survey data.

In 1979, the NCHS conducted the National Survey of Personal Health Practices and Consequences (NSPHPC). Wilson and Elinson (1981, p.223) reported that the NSPHPC:

> Verified the relationship between certain Alameda health practices and concurrent physical health status, as originally reported by Belloc and

> Breslow...The pertinent findings were: the more health habits people practiced, the less likely they were to report concurrent physical health problems; persons reporting themselves as physically active were less likely to report having had physical health problems; and the relationship between number of Alameda health practices and concurrent physical health status holds for younger (ages 20-44) and to a lesser extent also for older adults (ages 45-64).

The USAF has also explored the relationship between the Alameda health habits and health status. The Air Force Manpower and Personnel Center conducted a Health Survey among USAF personnel (AFMPC, 1977). A self-rating of general health was compared to the number of health habits practiced. The results showed a positive relationship between health status and the number of the health habits practiced among USAF personnel.

In relating health to productivity, Howard et al. hypothesized that there is a positive relationship between exercise, absenteeism and productivity.

> The effect of absenteeism on productivity is both direct and indirect. Directly, there is the lost productivity of either no one doing the job or a less experienced person doing the job. Indirectly, there is the cost of employee benefit plans, the excess work force carried in anticipation of absenteeism...and similar such costs.

The NCHS surveys collected data that contain some measures assumed to be relevant to absenteeism, such as,number of workdays lost for illness or injury, days of hospitalization, days ill or injured in bed and doctor visits. It is possible to perform cross-sectional analyses of the relationship between physical activity and these measures of productivity. Such an analysis of these survey data has not been published. In fact, further analysis of the NSPHPC to examine the relationship between exercise and selected health problems remains a long-term DHHS objective (PHS, 1983). This type of analysis would appear to have broad implications for physical fitness programs in both government and industry, particularly in view of the large national samples drawn in these NCHS surveys and the fact that these results can be readily generalized to other populations. Appendix B contains a proposal for this type of research. (More current survey data of this type do not appear to exist for either the national or USAF populations.) The results would provide the USAF some original data on the potential scope of the impact of physical fitness on productivity. Admittedly, these data would form only one measure of overall productivity. But, it is an important component in any productivity measurement scheme because it is applicable to all activities in an organization and it has implications for health care costs. Baseline data showing the impact of physical activity on readily quantified productivity measures like absenteeism are not currently available to the USAF.

NATIONAL HEALTH INTERVIEW SURVEY

Subjects

In 1977, during the annual NHIS, the NCHS directed the administration of a Health Habits Supplement to a subsample of the 110,000 NHIS respondents (NCHS, 1980). A house-to-house interviewing technique was used, and it obtained a 96 percent response rate. There were 22,842 respondents to the Supplement from the noninstitutionalized U.S. population aged 20 years and over. Approximately 47 percent of these respondents were men and 53 percent, women. Almost 43 percent were 20-34 years of age, while 30 percent were 35-49 and 27 percent, 50-64. In terms of education, 22 percent had less than 12 years; nearly 41 percent had 12 years, and 36 percent had more than 12 years. About 89 percent were white, 9 percent black, and 2 percent other.

Survey Instrument

The Supplement was designed to obtain data on the prevalence of seven preventive health practices. The questions on health practices, modified somewhat from those of the Alameda County study, included: (1) average number of hours of sleep per night, (2) frequency of eating breakfast, (3) frequency of eating snacks, (4) physical activity level relative to one's peers, (5) frequency and quantity of alcohol consumption, (6) smoking status (never smoked, former smoker, or current smoker) and amount smoked, and (7) body weight as compared with desirable body weight for a given height (NCHS, 1980). Respondents were asked to rate their own level of physical activity relative to other persons their own age: "more active," "about as active," or "less active." The Supplement also included questions concerning health status and use of health services, such as, the number of lost workdays for illness or injury, days of hospitalization, and doctor visits in the past year. Further, questions were asked about the number of days ill or injured in bed and days of work lost or school lost during the past two weeks. The value used for lost workdays was the greater value of either workdays lost or school days lost. Appendix C contains the selected survey items and choice of responses.

Statistical Procedure

A public use tape of this survey data was obtained from the NCHS for independent analysis by the authors. Since the ultimate purpose was to apply the results of this analysis to the USAF, it was necessary to match the NHIS subsample to the demographic characteristics of the USAF military population. In the NHIS subsample, only 47 percent of the respondents were male, compared to 93 percent in the USAF (in 1977 when the NHIS subsample was drawn). Also, 22 percent of the NHIS respondents had less than 12 years of education, versus less than 2 percent in the USAF. And about 57 percent of the NHIS respondents were 35-64 years of age, while the average age of USAF officer and enlisted personnel was 34 and 27, respectively (NCHSb, 1982; Air Force Magazine, 1977). Therefore, the NHIS subsample was matched to the USAF population on the basis of sex, education and age; those outside the USAF weight-height standards or with a physical disability were also eliminated. Appendix D contains the precise weighting procedure.

After weighting, the NHIS sample size was 3,751. It was divided into three groups based on level of physical activity (more active, about as active, or less active). Estimates of health care utilization (lost workdays, hospital days, bed days and doctor visits) were made based on age, sex and level of physical activity for the USAF-weighted national population. Analysis of covariance was used to evaluate the data. The statistical analysis was accomplished using the "ANOVA" program of the Statistical Package for the Social Sciences (SPSS), Version H (Nie, Hull, Jenkins, Steinbrenner, & Brent, 1975). Since this is exploratory research, a statistical significance level of p=0.10 was set. Age, education, income, marital status and geographic location (e.g. central city, other city or rural) variables were used as covariates. Mean values were adjusted for the independent variables of sex and race and the covariates listed above.

Results

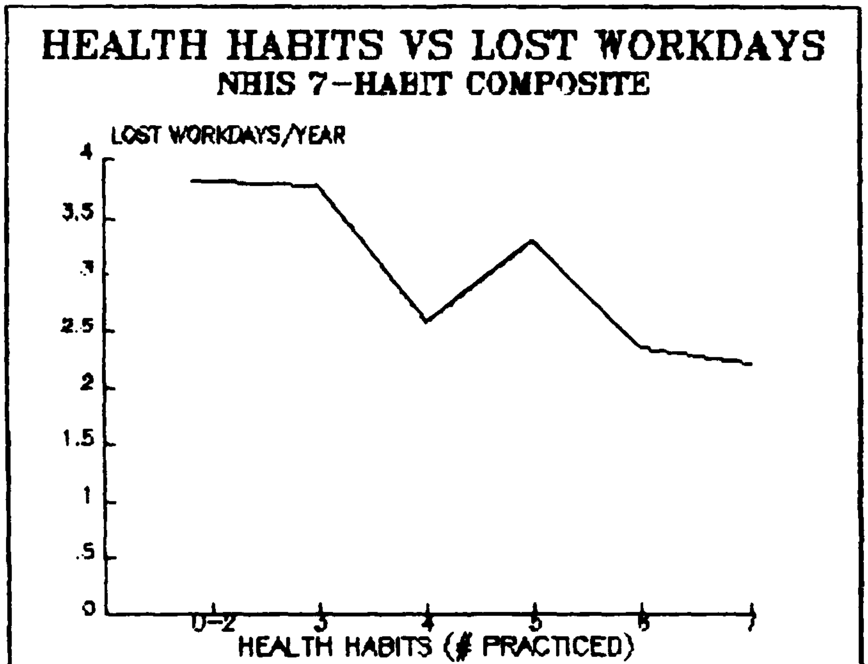
Physical Activity

There were no significant differences in the average number of lost workdays, hospital days, bed days, or doctor visits by level of physical activity (more active, less active, same). In fact, there were no consistent trends in the data.

Seven Health Habits Composite

To determine whether persons who followed all or several of the health practices occupied a more favorable position on the physical health spectrum than those who followed fewer or none of the habits, Belloc and Breslow (1972) constructed a score based on the seven health habit items. One point was credited for each of the following answers: usual hours of sleep 7 or 8; eat breakfast almost every day; eat between meals once in a while, rarely or never; report weight within the range of 5 percent under and 19.9 percent over the desirable standard for weight for men, or not more than 9.99 percent over for women; often or sometimes engage in active sports, swim or take long walks, or often garden or do physical exercises; drink not more than four drinks at a time; never smoked cigarettes. Otherwise, no points were credited. Respondents practicing zero, one or two of these health habits were combined into a single group to obtain a reasonable cell size. Analysis indicated that there were significant differences in the average number of lost workdays, hospital days and doctor visits by number of health practices (0-2,3,4,5,6,& 7). There was no significant difference among groups in the number of bed days.

Lost workdays. The average number of lost workdays differed significantly ($F(5,16)=3.722$, $p=0.002$) by the number of health practices. The relationship between the seven health habits composite and lost workdays appeared to be inverse, i.e., the greater the number of health habits practiced, the lower the number of days of work lost (Figure 5). People in the 0-2 health habits group lost almost two more workdays per year than those in the 7 habits group. There was a general linear relationship with a small abberation for the 5 habits group. Table A (Appendix F) contains a statistical summary.

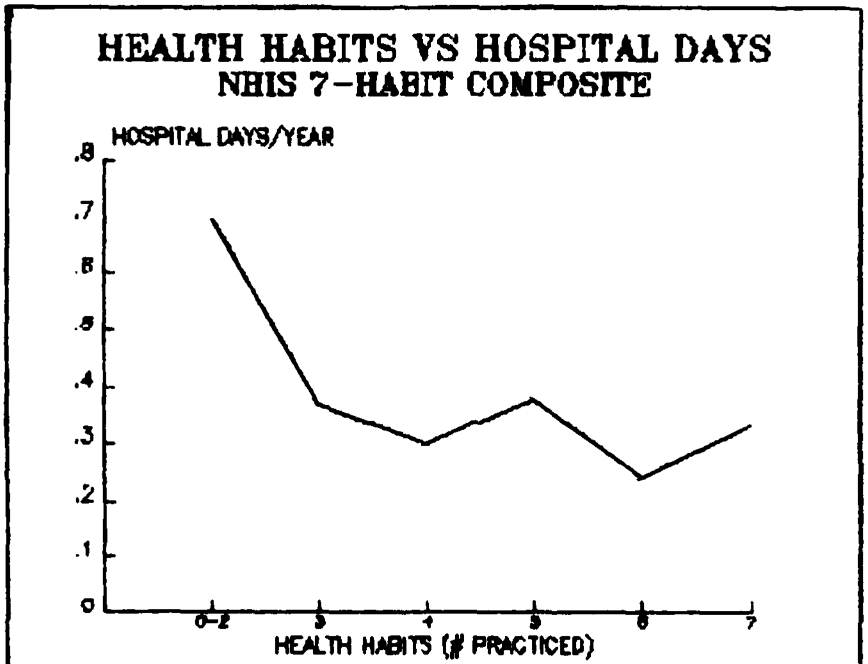


Mean	3.83	3.77	2.59	3.30	2.35	2.01
N	386	740	1006	861	487	141

Figure 5. Mean Lost Workdays for Seven Health Habits Composite

<u>Hospital days.</u> The average number of days of hospitalization differed significantly ($F(5,28)=2.329$, $p=0.040$) by the number of health practices. The relationship between the health habits composite and hospital days reflected a sharp difference between those in the 0-2 health habits group and individuals adhering to three or more habits (Figure 6). The 0-2 group had nearly double

the amount of hospital days of the other groups, suggesting the number of days spent in the hospital drops significantly with the practice of three or more health habits. However, there was little apparent difference among the groups with three or more health habits. (See Table B.)

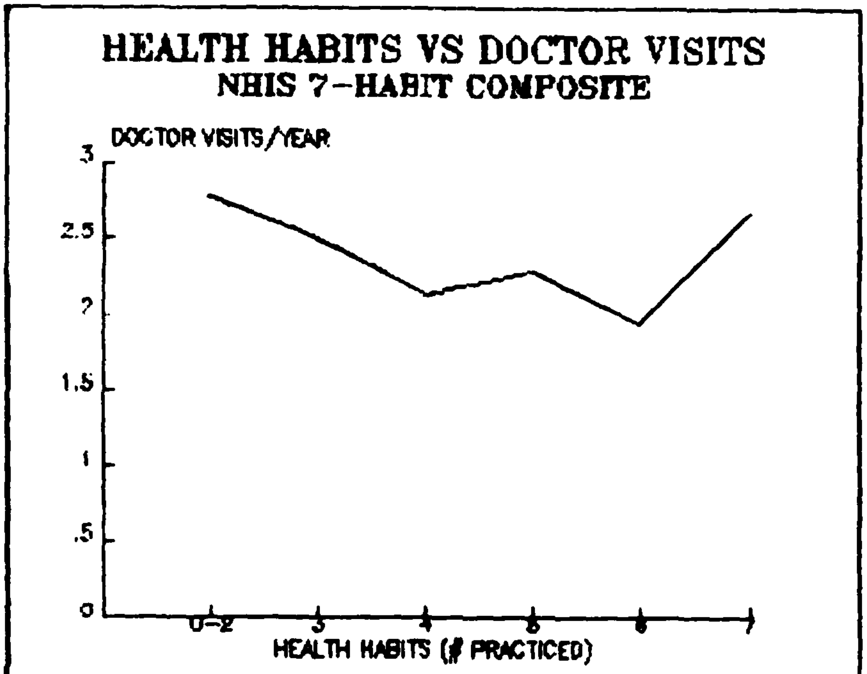


Mean	.70	.37	.30	.38	.24	.33
N	394	758	1034	869	491	141

Figure 6. Mean Hospital Days for Seven Health Habits Composite

<u>Doctor visits.</u> The average number of doctor visits differed significantly ($F(5,28)=2.241$, $p=0.048$) by the number of health practices. While there was a significant difference among certain of the group means, there was no clear relationship among them (Figure 7). For example, the group with 7 health habits had the

highest number of doctor visits, followed next by the group with 0-2 habits. (See Table C.)



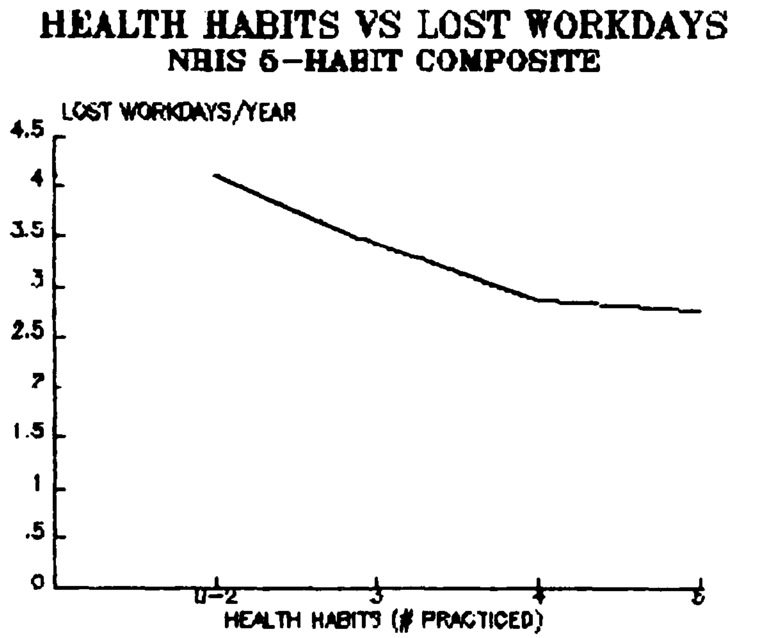
Mean	2.77	2.51	2.12	2.27	1.94	2.66
N	394	758	1034	869	491	141

Figure 7. Mean Doctor Visits for Seven Health Habits Composite

<u>Five Health Habits Composite</u>

A composite measure of five of the Alameda health habits was also formed; breakfast and snacking were omitted since subsequent research has not consistently corroborated their relationship with health (Wiley et al., 1980). There were significant differences in the average number of lost workdays, hospital days and doctor visits by number of health practices (0-2,3,4,& 5). Again, there was no significant difference in the number of bed days.

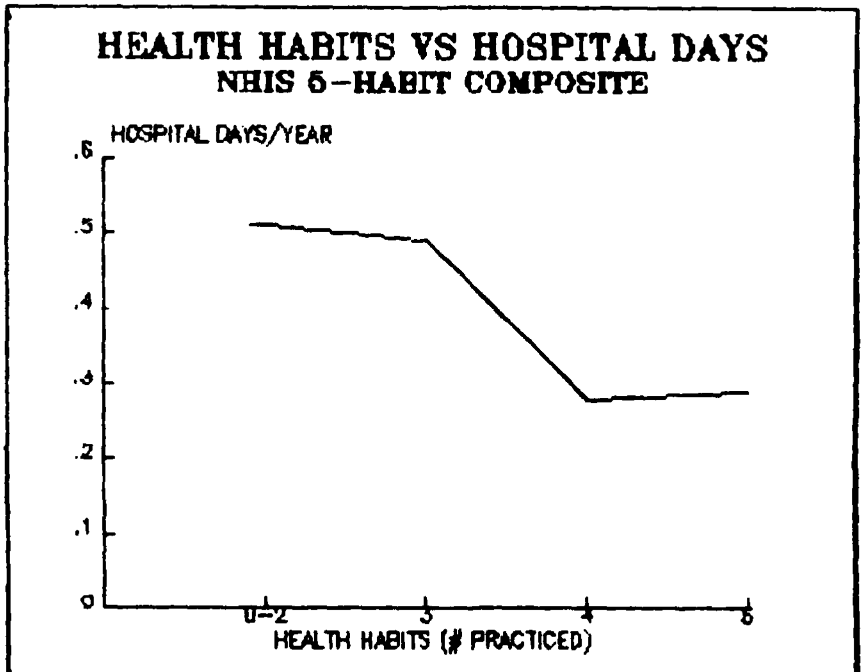
Lost workdays. The average number of lost workdays differed significantly ($F(3,20)=2.818$, $p=0.038$) by the number of health practices. The relationship between the five health habits composite and work lost appeared to be inverse and linear, i.e., the more health habits practiced, the fewer the days of work lost (Figure 8). The mean number of lost workdays was 1.33 less for the 5 habits group than the 0-2 habits group. (See Table D.)



Mean	4.10	3.41	2.87	2.77
N	323	964	144	891

Figure 8. Mean Lost Workdays for Five Health Habits Composite

Hospital days. The average number of days spent in the hospital differed significantly ($F(3,20)=2.584$, $p=0.052$) by the number of health practices. The relationship between this composite and hospital days also seemed to be inverse and linear, i.e., the more health habits practiced, the fewer days spent in the hospital (Figure 9). The amount of hospital days was small for all groups, and thus, the differences among groups were slight. Nonetheless, there was an apparent trend. (See Table E.)

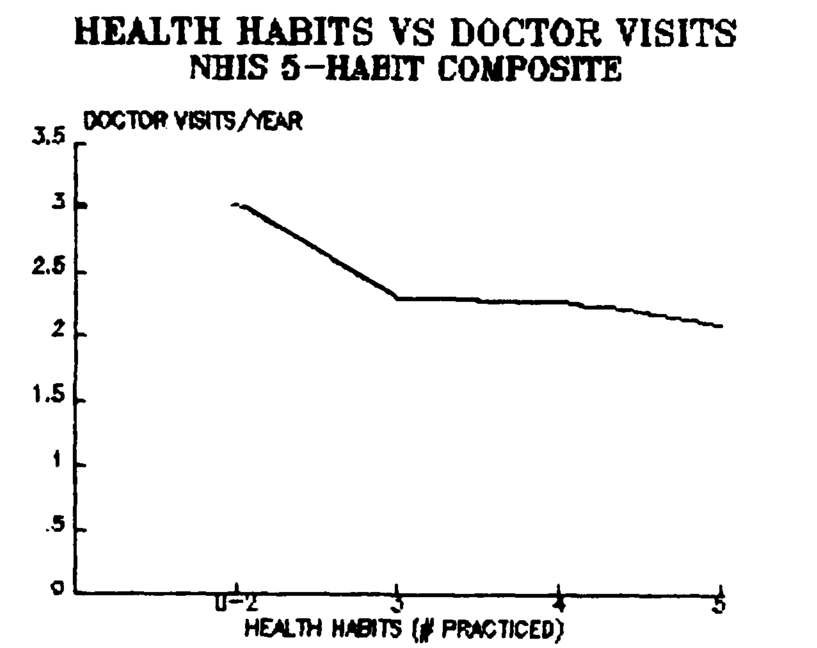


Mean	.51	.49	.28	.29
N	335	988	1439	899

Figure 9. Mean Hospital Days for Five Health Habits Composite

<u>Doctor visits.</u> The number of doctor visits differed significantly ($F(3,20)=3.474$, $p=0.015$) by the number of health practices. The relationship between this health composite and doctor visits also appeared to be an inverse one (Figure 10). In general, the more health habits practiced, the fewer doctor visits

made. For example, the number of doctor visits was nearly one less for the 5 habits group than the 0-2 group. However, the difference in number of doctor visits for the 3 habits group and the 4 habits group was negligible. Unlike the seven health habits composite (Figure 7), the five habits one showed an apparently clear trend. (See Table F.)



	0-2	3	4	5
Mean	3.03	2.30	2.29	2.09
N	335	988	1439	899

Figure 10. Mean Doctor Visits for Five Health Habits Composite

Results of Subsample of Ages 30-54

The relatively small absolute values of the health measures reported may be related to the youthfulness of the national sample once weighted to match the USAF population. It is widely accepted that younger people generally have fewer and less severe health problems. To examine this possibility, a subset of respondents aged 30-54 was drawn from the weighted sample and analyzed. The sample size was 1,451.

Physical Activity

There were no significant differences in the average number of lost workdays, hospital days, bed days or doctor visits by level of physical activity (more active, less active, and same). While not statistically significant, there appeared to be several trends. As the level of physical activity increased, the number of lost workdays, hospital days and doctor visits decreased. However, the average number of bed days appeared to increase as the level of physical activity increased.

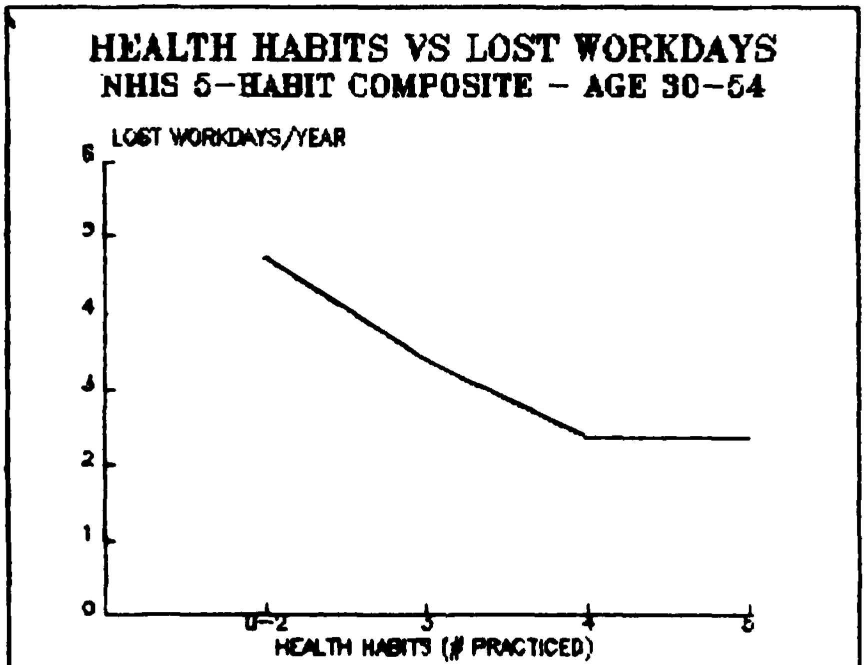
Seven Health Habits Composite

There were no significant differences in the average number of lost workdays, hospital days, bed days or doctor visits by number of health practices (0-2,3,4,5,6,& 7). While not statistically significant, the average number of lost workdays decreased as the number of health practices increased.

Five Health Habits Composite

There were significant differences in the average number of lost workdays by number of health practices (0-2,3,4,& 5 habits). There were, however, no significant differences in the number of hospital days, bed days or doctor visits. While not statistically significant, the average number of hospital days and doctor visits decreased as the number of health practices increased.

Lost workdays. The average number of lost workdays differed significantly ($F(3,12)=3.692$, $p=0.012$) by number of health practices. The relationship between the five habits composite and lost workdays was apparently inverse and linear, i.e., the more health habits practiced, the fewer days of work lost (Figure 11). For instance, the mean number of workdays lost was 2.36 days less for the 5 habits group than the 0-2 group. (See Table G.)



Mean	4.72	3.40	2.38	2.36
N	146	350	500	358

Figure 11. Mean Lost Workdays for Five Health Habits Composite Ages 30-54

In summary, the NHIS data provide some support for the idea that physical activity is related to increased productivity. Analysis did not reveal any significant differences by level of physical activity in the selected measures of productivity: lost workdays, hospital days, bed days or doctor visits. Several trends, though not statistically significant, seemed to appear in the subsample of respondents aged 30-54; the number of lost workdays, hospital days and doctor visits decreased as level of physical activity increased. Furthermore, when physical activity was combined with other health practices, the composite measure yielded significant differences in number of lost workdays, hospital days and doctor visits; number of bed days, though, was still not significant. The relationship between health habits, including physical activity, and the productivity measures of lost workdays and hospital days seemed to follow the predicted association. In other words, as the number of positive health habits increased, respondents lost less workdays and spent fewer days in the hospital.

The relationship between doctor visits and the composite of all seven health habits (physical activity, sleep, smoking, drinking, height-weight, breakfast and snacking) was not clear. However, when breakfast and snacking were omitted, the resulting five health habits composite showed significant differences that followed the predicted association, i.e., the more health habits practiced, the fewer doctor visits made. For respondents aged 30-54, the composite of five health habits reflected an even stronger significant difference in number of lost workdays with work loss apparently decreasing as number of health habits increase. While not statistically significant, the trend for the seven habits composite indicated that the number of lost workdays decreased as the the number of health practices increased. But, for ages 30-54, there were no significant differences on the physical activity measure or either of the health habits composites in number of hospital days, bed days or doctor visits. There were trends indicating a decrease in the number of hospital days and doctor visits as the number of health practices increased; however, they were not statistically significant.

From these results, we conclude that physical activity *only* in combination with other health habits is associated with increased productivity in a population similar to that of the USAF.

Discussion

From the survey results, physical activity alone would not appear to be associated with any of the selected measures of productivity. The measure of physical activity, however, provided only a rough approximation of the level of physical activity. Each respondent was asked to provide a self-assessment of his or her physical activity compared to contemporaries. Possible responses were: "more active," "less active," or "just as active." There are two methodological problems with this measure. First, the question calls for a subjective evaluation, which depends, of course, upon the validity and reliability of the respondent's answer. In this case, the survey data raise a question about the accuracy of the respondents' perception. Only six percent admitted to being less active than contemporaries, while the remainder were evenly split between the other two groups.

Second, responses to this question reflect relative, not absolute, levels of physical activity, and there is no way of determining how much physical activity the respondent actually gets. It is conceivable that some respondents in even the more active group do not get enough physical activity to gain the predicted personal or occupational benefits. Thus, it remains possible that more valid and reliable measures of physical activity may uncover the predicted association with productivity.

Composites of selected health habits, including physical activity, were related to productivity. Like the physical activity question, the practice of health habits is derived from self-reports. Undoubtedly, the responses also contain a certain amount of error due to deliberate falsification, carelessness, or uncertainty. It should be noted, however, that earlier work has shown there is a high degree of correspondence between self-reports and information contained in medical records. The evidence would not lead one to expect serious distortion of findings due to systematic error (Wiley & Camacho, 1980).

It is possible that the health habits other than physical activity produced the relationship with productivity. Yet, none of the health habits had a correlation coefficient greater than

0.05 when correlated with any of the productivity measures. Some investigators (Wiley & Camacho, 1980) have also found that the Alameda health habits in combination have a greater impact than does any one alone. Further, Heinzelmann et al. (1970) observed that physical activity influences the adoption of other health habits. These results strongly suggest that health practices are *interrelated*.

In general, the spread of absolute values between groups was small for the productivity measures, especially hospital days. The physically disabled and older (55-64) respondents were removed from the original sample by weighting it to match the USAF demographics. The remaining respondents were, thus, generally healthy and relatively young. Removal of the other respondents may have narrowed the range of the productivity measures, reducing the F ratio and increasing the p values (Wiley & Camacho, 1980). This select group of respondents, along with smaller group sizes, might also explain the loss of significance on most of the productivity measures for those aged 30-54. Indeed, for the subgroup of respondents aged 30-54, consistent differences in the predicted direction, though not statistically significant, began to emerge in number of lost workdays, hospital days and doctor visits by level of physical activity. Also, consistent trends in the predicted direction were apparent, though again not statistically significant, in the number of hospital days and doctor visits for the five health habits composite.

Hospital days, bed days and doctor visits were assumed to be valid measures of productivity, in addition to lost workdays. The correlation between each of these measures and lost workdays is not perfect, however. In fact in this survey, the correlations were not very high between lost workdays and hospital days ($r=0.367$), doctor visits ($r=0.299$) or bed days ($r=0.143$). Nonetheless, it still seems reasonable to assume that work time is often lost when people are in the hospital, ill or injured in bed or visiting the doctor.

Of course, the positive results for the health habits composites only show that health habits relate to these selected measures of productivity; the health habits do not necessarily cause an individual to be more productive. It can only be said that "productive" people tend to engage in more of these health habits than other people. Longitudinal studies are needed to define the relationships more clearly since cross-sectional data like that used in this study cannot demonstrate cause and effect. In spite of the methodological problems in this survey, these results are largely consistent with earlier research on the positive relationship between health habits and health status. Perhaps, it is the case that physical activity is associated with productivity *only* when acting in combination with other health habits. The possibility should certainly not be dismissed, especially in relatively young and healthy populations.

NATIONAL SURVEY OF PERSONAL HEALTH PRACTICES AND CONSEQUENCES

Subjects

In 1979, data for the NSPHPC were collected for the NCHS from a random sample of the U.S. population 20-64 years of age (NCHSa, 1982). Two waves of telephone interviews were conducted a year apart. Wave II was a follow-up of the original respondents in Wave I. Only Wave I data are analyzed here. There were 3,025 respondents in Wave I, representing an 81 percent response rate. Nearly 40 percent of the respondents were male and 60 percent, female. Other demographic characteristics, such as, age, education and race, were similar to those of the NHIS respondents previously discussed.

Survey Instrument

Numerous questions were asked about health practices and attitudes, health status and use of health services, and standard demographic variables (NCHSa, 1982). Only six of the Alameda County health practices were included; snacking between meals was omitted because "subsequent analyses of the Alameda data have cast some doubt on the strength of the relationship between snacking and health status" (NCHS, 1981, p. 29). There were numerous questions concerning the type and amount of exercise: swimming, jogging or running, cycling, walking, doing calisthenics, participating in other active sports or physically active hobbies. Questions were also asked about the number of days ill or injured in bed, days of hospitalization and doctor visits during the past year. The number of workdays lost for illness or injury was *not* measured. The selected survey items and choice of responses are in Appendix E.

Statistical Procedure

Again, a public use tape of the survey data was obtained from the NCHS for independent analysis by the authors. It was also necessary to weight the NSPHPC sample to match the USAF demographic characteristics for the same reasons as the NHIS subsample. The same weighting procedure used in the preceding survey analysis (Appendix D) was applied. The sample size after weighting was 933.

The weighted population was divided into groups based on level of physical activity or exercise category (swimming, jogging or running, cycling, walking, doing calisthenics, participating in other active sports or physically active hobbies). Estimates of health care utilization (hospital days, bed days and doctor visits) were made based on age, sex and level of physical activity or exercise category of the weighted national population. The rest of the statistical procedure was the same as in the NHIS.

Results

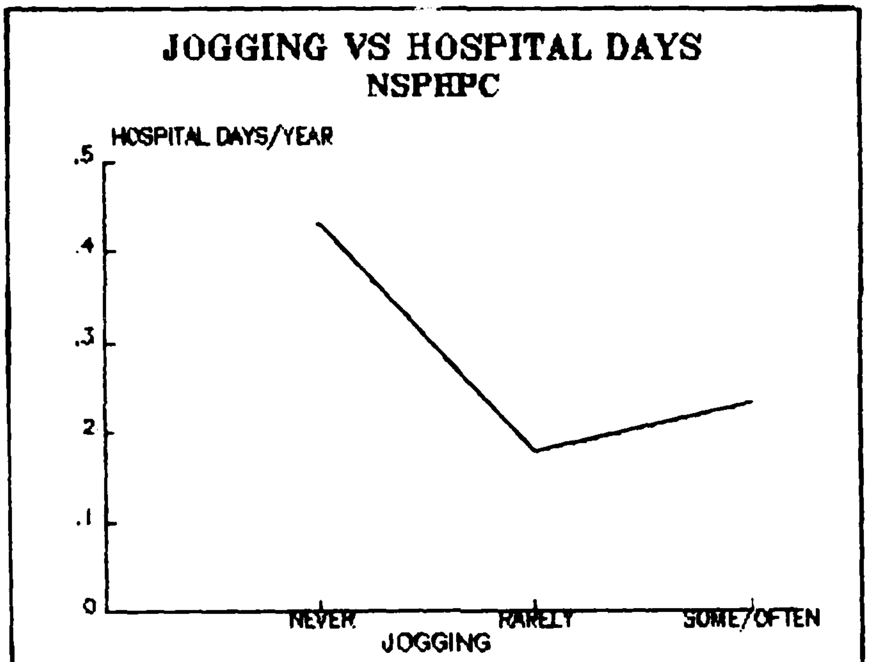
Physical Activity

There were no significant differences in the average number of hospital days, bed days or doctor visits by level of physical activity (much more/somewhat more active, much less/somewhat less active, and just as active).

Jogging

There were significant differences in average number of hospital days and doctor visits by levels of jogging (never, rarely, sometimes/often). There was no significant difference in the number of bed days.

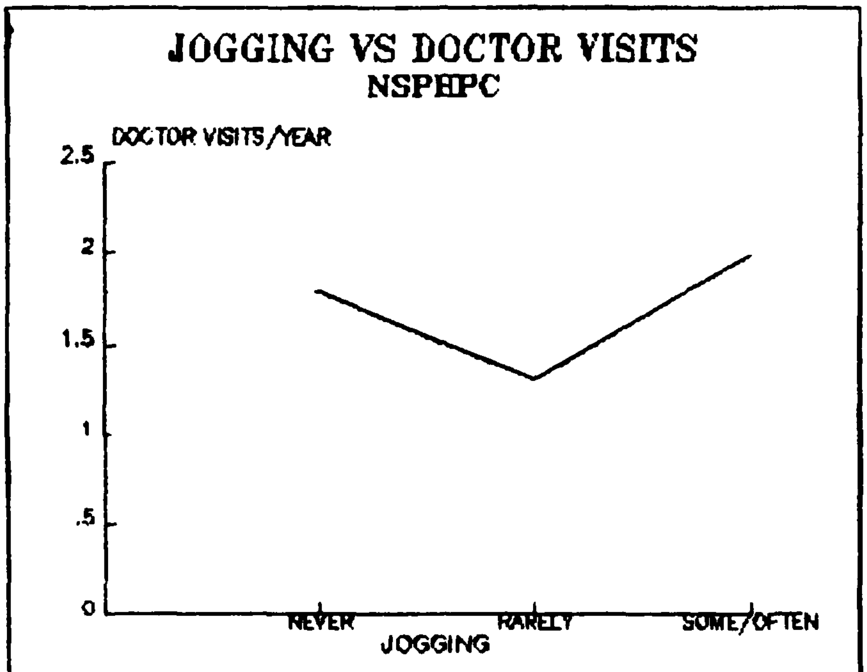
Hospital days. The average number of days of hospitalization differed significantly ($F(2,16)=2.319$, $p=0.099$) by frequency of jogging. The differences in absolute values among the groups were slight, but there was an apparent and significant trend (Figure 12). The relationship between jogging and hospital days was generally linear and inverse. For example, the mean number of hospital days of the group that never jogs was about double that of any other group. However, there was negligible difference between the groups that jog rarely and sometimes/often. (See Table H.)



Mean	.43	.18	.23
N	294	200	438

Figure 12. Mean Hospital Days for Jogging Frequency

<u>Doctor visits.</u> The average number of doctor visits differed significantly (F(2,16)=4.052, p=0.018) by frequency of jogging. Though there were significant differences among certain group means, the relationship between jogging and doctor visits was not clear (Figure 13). Those who jog sometimes or often made more doctor visits than any other group, including the group that never jogs. Those who rarely jog made the fewest doctor visits. (See Table I.)



Mean	1.79	1.31	1.99
N	294	200	438

Figure 13. Mean Doctor Visits for Jogging Frequency

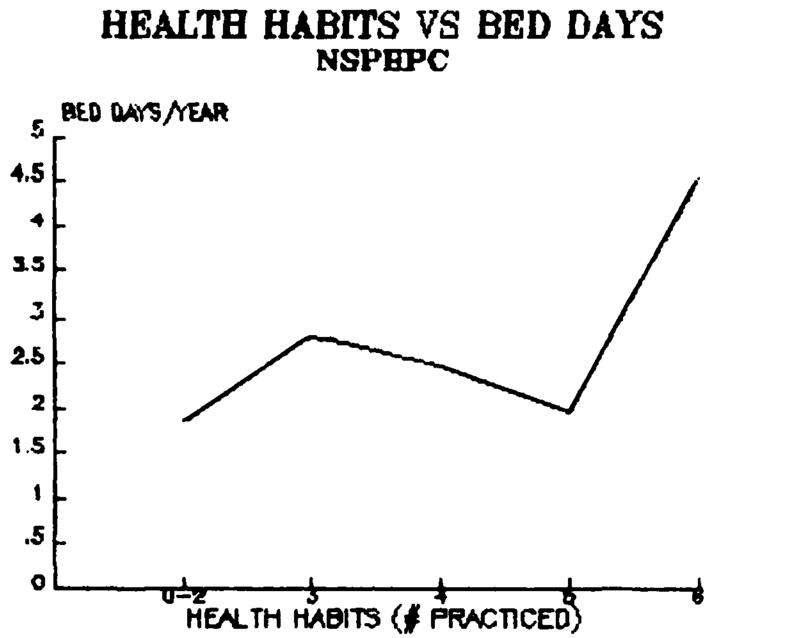
Exercise Composite

There were no significant differences in the average number of hospital days, bed days or doctor visits by level of the other individual categories of aerobic exercise. However, a composite score of these exercises was formed to assess the impact of strenuous exercise in general. This composite was based in part on a methodology developed by Paffenbarger (1978). The exercises included were: jogging, swimming, cycling, long walks, calisthenics, physically active hobbies and sports. For each exercise question, one point was assigned for a response of "never," two points for "rarely," three for "sometimes" and four for "often." To weight the more strenuous exercises, the scores for jogging, swimming, cycling and long walks were doubled. The scores were added so that each respondent had a single score. The scores, ranging from a low of 11 to a high of 44, were subdivided into groups so the distribution of respondents approximated that of the exercise composite before weighting. The exercise groups were: low (11-26 points), medium (27-31) and high (32-44). Analysis indicated that there were no significant differences in average number of hospital days, bed days or doctor visits by levels of exercise (low, medium, and high).

Six Health Habits Composite

As in the preceding analysis of the NHIS, a composite score of the Alameda health habits was formed. However, snacking was omitted. This composite measure showed significant differences among the group means (0-2,3,4,5,& 6 health habits) for bed days. There were no significant differences for hospital days or doctor visits.

Bed days. The average number of days ill or injured in bed differed significantly ($F(4,24)=3.182$, $p=0.013$) by number of health practices. The relationship between bed days and these six health habits was not consistent (Figure 14). For instance, the 6 habits group had the highest mean of bed days, while the 0-2 habits group had the lowest mean. However, the 5 habits group had the second lowest mean. (See Table J.)



Mean	1.87	2.80	2.48	1.98	4.52
N	117	243	252	205	96

Figure 14. Mean Bed Days for Six Health Habits Composite

<u>Five Health Habits Composite</u>

Another composite of the health habits - with snacking and breakfast omitted as in the NHIS analysis - was formed. There were no significant differences in the number of hospital days, bed days or doctor visits by number of health practices (0-2,3,4,& 5).

Results of Combining Groups to Increase Cell Size

The NSPHPC sample size was only about one-quarter that of the NHIS, after weighting both surveys. Observations of the NSPHPC data seem to indicate that if certain groups were combined, more meaningful and possibly significant results might be obtained. The results of such an analysis follow.

Physical Activity

There were significant differences in average number of hospital days by level of physical activity (much less/somewhat less/just as active versus somewhat more/much more active). There were no significant differences in number of bed days or doctor visits.

Hospital days. The number of days of hospitalization differed significantly ($F(1,12)=2.793$, $p=0.095$) by level of physical activity. The absolute difference between group means was small. Still, the less active group (.45) spent nearly twice the number of days in the hospital as the more active group (.24). (See Table K.)

Jogging

There were significant differences in average number of hospital days by level of jogging (never versus rarely/sometimes/often). There were no significant differences in number of bed days or doctor visits.

Hospital days. The average number of days of hospitalization differed significantly ($F(1,12)=4.474$, $p=0.035$) by frequency of jogging. Again, the absolute difference between group means was small. Nevertheless, the non-jogging group (.43) spent double the number of days in the hospital of the jogging group (.21). (See Table L.)

Exercise Composite

There were significant differences in average number of doctor visits by level of exercise (low/medium versus high). There were no significant differences in number of hospital days or bed days.

Doctor visits. The average number of doctor visits differed significantly ($F(1,12)=4.125$, $p=0.043$) by the level of exercise. In this case, the high exercise group (1.99) made more doctor visits than the low/medium group (1.62). (See Table M.)

In summary, the NSPHPC data provide little support for the relationship between physical activity and productivity. Analysis did not reveal any significant difference between level of physical activity or the exercise composite and the selected measures of productivity: hospital days, bed days and doctor visits. Frequency of jogging or running did reflect significant differences in the number of hospital days and doctor visits; however, only the former revealed an apparent trend, and it was as predicted: the more one jogs, the fewer hospital days. When physical activity was combined with five other common health habits (sleep, smoking, drinking, height-weight, and breakfast), the composite did not yield any significant differences for hospital days or doctor visits. While the composite's relationship with bed days was significant, the trend was not consistent. Moreover, with breakfast omitted, the five health habits composite did not indicate any significant differences at all.

Aggregating subgroups to increase size produced significant differences among the physical activity subgroups in the number of hospital days. It also produced a more significant difference among the jogging subgroups in the number of hospital days. The predicted association - hospital days decrease with increased physical activity or jogging - also appeared. Moreover, the exercise composite showed significant differences among groups in the number of doctor visits, but the apparent relationship was contrary to the expected relationship of doctor visits decreasing with increased exercise.

From these results, it would be difficult to conclude that physical activity, either alone or in combination with other health habits, is measurably associated with increased productivity.

Discussion

The NSPHPC results revealed little relationship between physical activity and productivity. Since the measure of physical activity was comparable to that used in the NHIS, the same methodological problems were encountered. Only 18 percent of the respondents in this survey reported being much less active, somewhat less active or just as active.

Unlike the NHIS, The NSPHPC included more specific measures of physical activity, such as the frequency of jogging, swimming, cycling, walking, etc. Possible responses were: "never," "rarely," "sometimes," or "often." Analysis of jogging as well as a composite of these exercises revealed only one significant relationship with the productivity measures. The one instance was that jogging showed a barely significant and inverse relationship with hospital days; thus, the number of hospital days tended to decrease as jogging increased.

Methodological problems similar to those with physical activity may also apply to these exercise questions. They also call for subjective assessments without an objective standard for comparison. Further, for the exercise composite, respondents participating rarely or sometimes in several kinds of exercises would be placed in a higher group than someone who performed fewer exercises often. Thus, a physically fit but exclusive jogger would be placed in a lower group than the physically unfit who participate rarely or sometimes in many of the exercises. Still, it should be noted that despite these potential problems, there was a more even distribution among both the exercise composite and jogging subgroups than for the physical activity measure.

There are other plausible explanations for the failure of the NSPHPC data to confirm the NHIS results. As mentioned earlier, the weighted NSPHPC sample was only one-quarter the size of the weighted NHIS sample. Observations of the raw survey data seemed to indicate that if subgroups were combined to increase the number of respondents, then statistically significant differences might be identified. In fact, this aggregation produced significant differences among the physical activity and jogging subgroups for hospital days. Further, the predicted association - hospital days decrease with increased physical activity or jogging - also appeared. The exercise composite, too, showed significant differences for doctor visits, but the apparent relationship was contrary to the anticipated decrease in doctor visits with increased exercise. Perhaps, people who exercise strenuously visit the doctor more often because they are more conscious of their health. Speaking hypothetically, a weighted NSPHPC sample with the same distribution of responses but the size of the weighted NHIS sample would have reflected many of the predicted associations between physical activity, jogging, the exercise component and the productivity measures.

Other possible sources of the difference between the NHIS and NSPHPC results include the two-year difference in time between the administration of these surveys and the method of collecting the survey data (telephone versus personal interview), though neither of these possibilities seems likely. Lastly and probably of greater consequence, the NSPHPC did not collect the measure of lost workdays, which is most closely tied to productivity. The only available measures of productivity were hospital days, bed days and doctor visits. Their relationship with lost workdays has not been clearly established, but rather assumed. In view of the low correlation between lost workdays and these other measures in the NHIS, it is possible that significant differences for lost workdays would have been identified if it had been measured. In spite of the lack of positive results, the connection between these health measures and productivity still seems to make sense.

These results do not refute the hypothesis that physical activity is related to productivity. Rather, there are substantial indications in the results that the anticipated and desired relationship does exist. However, it appears that it will take more valid and reliable measures of physical activity than used in this survey to demonstrate the predicted relationship with productivity. Better survey design and methodology as well as large representative samples will also be needed.

U.S. AIR FORCE HEALTH SURVEY

As discussed earlier, the USAF Health Survey demonstrated that the number of health habits practiced by USAF personnel is positively related to their self-assessment of general health (AFMPC, 1977). Unfortunately, the survey did not contain any measures of illness, absenteeism or any other aspect of productivity that could be compared to the weighted national data. Furthermore, the USAF survey did not measure physical activity in comparison to one's contemporaries like the NHIS and NSPHPC. However, all three surveys did measure the practice of health habits, with slight differences aside from physical activity. For comparison of health habits in the three samples, USAF respondents were divided into three categories of exercisers (more, less and middle) to be "similar" to the other surveys' categories of more, less or just as active.

Even with only rough comparability of the physical activity measures, comparison of the data indicated that the USAF sample had a similar distribution in number of health practices as the weighted national populations. For instance, on the five health habits composite, the USAF, NHIS and NSPHPC distributions were, respectively: 5 habits practiced, 14.6%, 12%, 19.6%; four habits, 35.6%, 28.7%, 34.9%; three habits, 31.7%, 35.2%, 31.8%; and two or less habits, 18.1%, 24.2%, 13.7%. Distributions on the six and seven health habits composites were similar to the one for five habits. The distributions by sex, age and education were also similar for all three samples. The similarity in health practices, together with the carefully matched demographic characteristics, of the USAF and two weighted national samples suggests that similar trends in productivity measures would have been identified if the USAF survey had contained such measures.

SUMMARY

Two national surveys, the NHIS and NSPHPC, were analyzed to assess the relationship between selected measures of physical activity, health habits and productivity. Table 4 summarizes the survey results, after weighting the data to match the USAF demographic characteristics for age, sex, education, weight-height standards and absence of physical disability. The selected measures of productivity included: lost workdays for illness or injury (NHIS only), days of hospitalization, days ill or injured in bed and doctor visits. The latter three measures are assumed to relate to a substantial degree with absenteeism which can, of course, directly affect productivity.

TABLE 4

SUMMARY OF SIGNIFICANT SURVEY RESULTS
(P < 0.10)

VARIABLE	NHIS (1977) FULL SAMPLE	NHIS (1977) AGE 30-54	NSPHPC (1979) NORMAL	NSPHPC (1979) AGGREGATION
PHYSICAL ACTIVITY	NO SIGNIFICANT RESULTS	NO SIGNIFICANT RESULTS	NO SIGNIFICANT RESULTS	HOSPITAL DAYS (P=.095) BED DAYS ‡ DOCTOR VISITS ‡ LOST WORKDAYS ♦
JOGGING	NOT MEASURED	NOT MEASURED	HOSPITAL DAYS (P=.099) DOCTOR VISITS (P=.018) BED DAYS ‡ LOST WORKDAYS ♦	HOSPITAL DAYS (P=.035) DOCTOR VISITS ‡ BED DAYS ‡ LOST WORKDAYS ♦
EXERCISE COMPOSITE	NOT MEASURED	NOT MEASURED	NO SIGNIFICANT RESULTS	DOCTOR VISITS (P=.043) HOSPITAL DAYS ‡ BED DAYS ‡ LOST WORKDAYS ♦
7 HEALTH HABITS COMPOSITE	LOST WORKDAYS (P=.002) HOSPITAL DAYS (P=.040) DOCTOR VISITS (P=.040) BED DAYS ‡	NO SIGNIFICANT RESULTS	NOT MEASURED	NOT MEASURED
6 HEALTH HABITS COMPOSITE	NOT MEASURED	NOT MEASURED	BED DAYS (P=.013) HOSPITAL DAYS ‡ DOCTOR VISITS ‡ LOST WORKDAYS ♦	NOT MEASURED
5 HEALTH HABITS COMPOSITE	LOST WORKDAYS (P=.038) HOSPITAL DAYS (P=.052) DOCTOR VISITS (P=.015) BED DAYS ‡	LOST WORKDAYS (P=.012) HOSPITAL DAYS ‡ DOCTOR VISITS ‡ BED DAYS ‡	NO SIGNIFICANT RESULTS	NOT MEASURED

NOTES: ‡ NOT STATISTICALLY SIGNIFICANT. ♦ NOT MEASURED.

The crude measure of physical activity - comparing one's own activity with contemporaries - only indicated a relationship with the productivity measures in one instance. When respondents were divided into two broad groups, the more active group had half the number of hospital days of the less active group. Differences were not apparent, though, for more narrow distinctions between physical activity levels. For more specific measures of physical activity, only frequency of jogging showed any of the predicted associations; hospital days for joggers appeared to be about half of that of non-joggers. Once more, however, this difference was not evident for less broad distinctions between jogging levels. Further, the number of doctor visits seemed to increase, rather than decrease as predicted, for those who exercised more strenuously.

When physical activity was combined with other common health habits (sleeping, smoking, drinking alcohol, weight-height breakfast and snacking), associations with productivity were found in the NHIS. Both lost workdays and hospital days showed the predicted relationship: as the number of health practices increased, lost workdays and hospital days decreased. By omitting breakfast and snacking - some investigators have failed to confirm their association with health status - the composite of health habits indicated the predicted association with doctor visits, in addition to lost workdays and hospital days. For ages 30-54, the composite of five health habits indicated the expected relationship only with lost workdays. The NSPHPC, with one-quarter the sample size of the NHIS, failed to confirm the relationship between health habits and the productivity measures.

Overall, these survey findings suggest that in comparatively young and healthy populations, the influence of physical activity alone may not be evident, particularly in health-related measures of productivity. However, physical activity and other common health habits seem to influence each other, producing a synergistic effect greater than the sum of the habits. This effect may be reflected in improved health and thus productivity even in young and healthy populations.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

In this chapter, we present a summary of conclusions from the literature and survey analyses concerning the effects of physical activity on productivity. Recommendations based on these conclusions are also offered.

Conclusions

Literature Review

Physical activity appears to influence productivity in three ways: increased energy, positive attitudes and feelings, and better health. First, the literature consistently shows that regular physical activity increases energy and decreases fatigue, whether physical or mental. Energy and fatigue, in turn, may influence the effort put into work and, thus, productivity. The nature of the job, however, determines how significant a role energy and fatigue will play in productivity. In jobs requiring high energy expenditure, productivity seems to be greater for the physically fit. In other jobs, the relationship is not as evident. Today, most jobs require a relatively small expenditure of energy. Thus, the differences between the fit and unfit are masked by more dominant influences on productivity, such as, motivation, rewards and recognition.

. The USAF, with its diversity of occupational skills, has both high and low energy jobs. Special operations, combat control, pararescue, and flight-line maintenance are a few of the USAF specialties requiring the expenditure of high amounts of energy. However, the majority of USAF skills, particularly in the support areas like administration, personnel and supply, rarely require high energy during peacetime. Nonetheless, if energy expended in duty performance differs substantially from peace to wartime, then fitness in people with desk jobs may become very important because of readiness requirements. For example, administrative personnel may be used as security police augmentees, suddenly requiring greater energy expenditure. In the short run, other factors, such as fear or motivation, may dominate the effects of fitness in these augmentees. However, if high levels of energy must be sustained as in wartime, the effects of fitness are likely to become evident in the long run.

Stress, in terms of mental fatigue, seems to have the same impact on productivity as the need for high energy. Thus, productivity under substantial stress appears to be higher in physically fit workers. Unlike energy, it may not be realistic to divide occupations into categories by level of stress imposed. While a few jobs may uniformly impose stress (e.g., air traffic controllers), stress frequently depends on individual coping mechanisms and other unique situational factors (e.g., personality of the boss) as much as job requirements.

Second, research consistently suggests that physical activity improves attitudes and feelings toward work and the organization. Many studies further indicate that physically active employees are personally convinced that physical activity improves work performance and productivity. However, the connection between attitudes and feelings toward work and productivity remains theoretical. There is a theoretical link between physical activity and attitudes and feelings toward work and the organization. These attitudes and feelings are, in turn, supposedly linked to identification with the company, commitment to company goals, loyalty, job satisfaction, and cohesion. Finally, job satisfaction and these other variables may be linked to productivity. However, investigators have not been able to determine and quantify the relationship of these multiple psychological links between fitness and productivity. The relationship of these intermediate links must be demonstrated before conclusive evidence of the psychological benefits of physical activity and the impact on productivity can be proven.

The literature consistently shows that physical activity, through its long-term impact on mortality and morbidity, may lead to increased productivity; this assumes productivity is measured cumulatively over a worker's lifetime. In general, increases in fitness levels appear to reduce the risks of illness and injury and coronary heart disease over the long run. These reductions typically yield lower rates of absenteeism and turnover and, thus, increase productivity.

Finally, several points need emphasis. Physical activity is only one of many factors affecting productivity. Even in physically or mentally demanding work, physical activity is not likely to be the dominant factor in productivity. Other factors, such as, motivation, may always dominate or mask the effects of physical activity. In those situations when physical activity is associated with productivity, the association is not universal, rather it applies only in general. Physical activity apparently affects people differently and can even cause adverse reactions to health in some people. Moreover, it is still not clear what type and how much physical activity is enough for the impact on health or productivity to become apparent. For instance, does regular physical activity short of that necessary for aerobic fitness improve productivity? Is there a difference in productivity measures by the degree or type of fitness? Lastly, appropriate productivity measures have also become increasingly difficult to obtain as the economy shifts from manufacturing to information and services. Perhaps, some of these issues will be resolved by the research currently underway at Tenneco, Prudential, Kimberly-Clark, Johnson and Johnson and other companies in industry.

Survey Results

Certain aspects of the relationship between physical activity and productivity were evident in two recent surveys of the U.S. population. However, when weighted to match USAF demographic characteristics (military only), the survey data revealed little difference between levels of physical activity and any of the measures of productivity: workdays lost for injury or illness, days of hospitalization, days injured or ill in bed and doctor visits. In one case, when respondents were divided into two broad groups, physical activity did show the predicted association with productivity; the more active group had half the number of days of hospitalization of the less active group.

More specific measures of physical activity, such as frequency of jogging, swimming, cycling, etc., did not indicate the expected significant differences, either. Only jogging showed any of the predicted associations - days of hospitalization for joggers appeared to be about half of that of non-joggers. But, even this association was apparent only when all respondents were divided into two broad groups; it was not evident for more specific distinctions, such as, between groups of "rare" joggers and "sometimes/often" joggers. Furthermore, the number of doctor visits seemed to increase, rather than decrease as expected, for those who exercised more strenuously.

In the NHIS, when physical activity was combined with other common health habits, especially sleeping, smoking, drinking alcohol and weight-to-height ratio, several of the anticipated associations with productivity were found. As the number of health habits increased, the respondents had fewer lost workdays, days of hospitalization, and doctor visits. However, data from the NSPHPC did not confirm the relationship between health habits and the productivity measures found in the NHIS.

These results apply to a U.S. population which has been matched to USAF demographic characteristics of age, sex, education, weight-height standards and physical disability standards for military personnel. Comparison with available USAF survey data suggests similar results would be obtained in a USAF sample. With a relatively young force continually screened against strict health standards, the USAF should expect to reap the benefits of the generally good health enjoyed by its personnel. Indeed, in a population like this, the demands for health care are expected to be small, as they also appear to be in the national population. Thus, it should be difficult to identify differences for productivity measures based upon health, such as, days of hospitalization, days ill or injured in bed or doctor visits. Indeed, the NHIS and NSPHPC results revealed few of the anticipated associations between physical activity and productivity. However, physical activity as part of a healthy lifestyle in general does seem related to productivity, based on the NHIS results and the literature. In fact, physical activity and other health habits appear to be interrelated. When combined, these habits seem to generate a synergism that multiplies their separate impacts on productivity even in young and healthy populations. Perhaps, as Howard et al. predicted, this relationship must be studied over a longer period than the one-year span considered in these two surveys for the benefits of health habits, including physical activity, to appear conclusively.

Recommendations

Energy

The level of physical activity is likely to influence productivity in a number of USAF skills requiring high energy. These skills need to be identified, and fitness standards should be developed based on wartime requirements. Further, research is necessary to identify the level at which physical activity begins to affect productivity; it should also determine whether productivity increases as level of physical activity increases from sub-fitness to "high" fitness. The impact of physical activity on mental fatigue and stress also warrants further st[illegible], particularly in critical duty positions.

Attitudes/Feelings

The interrelationships of the theoretical psychological links between physical activity and productivity require research. Until these links are documented, the psychological benefits of physical activity in terms of productivity cannot be demonstrated conclusively. One possible USAF contribution would be a study of the effects of physical activity on attitudes and feelings toward work and the Service. Since USAF personnel obtain their physical activity largely on their own, there would be no confounding effects from participation in a fitness program run by the organization.

Health

The influence of physical activity on the practice of other health habits and the impact of physical activity relative to other health habits on productivity should be investigated. Research should also determine the level of physical activity necessary to influence the illness and injury process and whether further increases in physical activity produce corresponding increases in health.

The World Health Organization includes the social, as well as the physical and mental, dimensions in its definition of health (WHO, 1978). In the weighted NSPHPC data, significant differences were noted on the social network index (described in NCHSa, 1982) which measures the number of social ties and their relative importance to health status. Though beyond the scope of this study, further analysis of these data may reveal associations between social networks, health status and health-related measures of productivity.

General

The main deficiency of the literature on physical activity and productivity is the shortage of studies employing rigorous scientific procedures. Further research should avoid self-reporting of fitness effects and emphasize methodologies designed to show cause and effect. Longitudinal studies using random assignment of subjects to control groups offer substantial promise in this regard. Additional productivity measures also need to be developed. Since universal productivity measures are not likely, research should concentrate on measures relevant to specific jobs. In addition, correlation of job specific productivity measures with absenteeism, turnover, job satisfaction, etc., may provide additional insights. Further, a large sample size may be necessary to overcome the high dropout rate common to this type of research and to permit reasonable sample size for statistical analysis.

As our final recommendation, we believe the USAF should encourage its military and civilian personnel to adopt and maintain a healthy lifestyle, in addition to regular physical activity. Regular physical activity is, of course, an important component of a healthy lifestyle. The literature consistently indicates that the health benefits of exercise, both in the short and long term, outweigh the risks of inactivity. In addition, the combination of physical activity with other health habits appears to create a synergistic effect, where the whole is greater than the sum of its parts. This synergism seems strong enough - even in a youthful and healthy population - to have a positive influence on productivity where physical activity alone may not. These health benefits are frequently reflected in measures of productivity, such as, absenteeism and turnover. This obviously reinforces the need for the USAF aerobics program for military personnel. Moreover, it underscores the need for a fitness program for USAF civilian personnel.

REFERENCES

Air Force Magazine. U.S. Air Force almanac. Air Force Magazine, May 1977, pp. 134; 138.

American College of Sports Medicine (ACSM). Position statement on the recommended quantity and quality of exercise for developing and maintaining fitness in healthy adults. Medicine and Science in Sports, 1978, 10, 7-10.

American College of Sports Medicine, Guidelines for graded exercise testing and exercise prescription. Philadelphia, Pa.: Lea & Febiger, 1980.

Andrews, F. M., & Crandall, R. The validity of measures of self-reported well-being. Social Indicators Research, 1976, 3(1), 1-9.

Astrand, P. O., & Rodahl, K. Textbook of Work Physiology. New York: McGraw-Hill, 1977.

Banister, E. W. Health, fitness and productivity. The Labour Gazette, 1978, 78(9), 400-407.

Belloc, N. B. Relationship of health practices and mortality. Preventive Medicine, 1973, 2, 67-81.

Belloc, N. B. & Breslow, L. Relationship of physical health status and health practices. Preventive Medicine, 1972, 1, 409-421.

Bennett, B. L., & Bondi, K. R. The relationship of job performance to physical fitness and its application to U. S. Navy submariners (RN962-RWUF58524-MF58524006-2104). Groton Submarine Base, Ct.: Naval Submarine Medical Research Laboratory, Naval Medical Research and Development Command, September 1981, pp. 1-20.

Bjurstrom, L. A., & Alexiou, N. G. A program of heart disease intervention for public employees. Journal of Occupational Medicine, 1978, 20(8), 521-531.

Blair, S. N., Pate, R. R., Howe, H. G., Blair, A. E., Rosenberg, M., & Parker, G. M. Leisure time physical activity and job

CONTINUED

satisfaction. Medicine and Science in Sports, 1979, 11(1), 105. (Abstract)

Bowne, D. W., Hellman, E. E., Richardson, H. E., Clarke, A. E., Bransford, P. E., Russell, M, & Goodrick, G. K. Physical fitness programs for industry: extravagance or wise investment? Prudential Insurance Co. Report, Houston, Tx., 1981.

Breslow, L., & Enstrom, J. The persistence of health habits and their relationship to mortality. Preventive Medicine, 1981, 9, 469-483.

Cady, L. D., Bischoff, D. P., O'Connell, E. R., Thomas, P. C., & Allan, J. H. Strength and fitness and subsequent back injuries in firefighters. Journal of Occupational Medicine, 1979, 21(4), 269-272.

Ciuca, A. Longevity and environmental factors. Gerontologist, 1967, 7, 252-256.

Cooper, K. H., Aerobics, New York: M. Evans and Co., 1968.

Cooper, K. H., The Aerobics Program For Total Well-Being, New York: M. Evans and Co., 1982.

Corrigan, D. L., Ismail, A. H., & Young, R. J. Effect of habitual exercise on total health as reflected by non-accidental insurance claims. American Association of Fitness Directors in Business and Industry (AAFDBI), 1980, 3(1), 7-8.

Cox, M., Shephard, R. J., & Corey, P. Influence of an employee fitness programme upon fitness, productivity and absenteeism. Ergonomics, 1981, 24(10), 795-806.

Davey, C. P. Physical exertion and mental performance. Ergonomics, 1973, 16, 595-599.

Davies, C.T.M. Relationship of maximum aerobic power output of productivity and absenteeism of east african sugar cane workers. British Journal of Industrial Medicine, 1973, 30, 146-154.

CONTINUED

Dedmon, R. E. Outcome evaluation and accountability in corporate fitness programs. American Association of Fitness Directors in Business and Industry, 1980, 3(1), 2.

Dedmon, R. E., & Smoczky, C. M. Kimberly-Clark's health management program: update 1983, Kimberly-Clark Co. Report, Neenah, Wi., 1983.

Donoghue, S. The correlation between physical fitness, absenteeism and work performance. Canadian Journal of Public Health, 1977, 68(3), 201-203.

Driver, R. W., & Ratliff, R. A. Employers' perceptions of benefits accrued from physical fitness programs. Personnel Administrator, August 1982, pp. 21-22; 24, 26.

Durbeck, D. C., Heinzelmann, F., Schacter, J., Haskell, W. L., Payne, G. H., Moxley, R. T., Nemiroff, M., Limoncelli, D. D., Arnold, L. B., & Fox, S. M. The national aeronautics and space administration-U.S. public health service health evaluation and enhancement program. The American Journal of Cardiology, 1972, 30, 784-790.

Edwards, S. E., & Gettman, L. R. The effect of employee physical fitness on job performance. Personnel Administrator, November 1980, pp. 41-44; 61.

Eichner, E. R. Exercise and heart disease epidemiology of the exercise hypothesis. The American Journal of Medicine, 1983, 75, 1008-1023.

Elsayed, M., Ismail, A. H., & Young, J. R. Intellectual differences of adult men related to age and physical fitness before and after an exercise program. Journal of Gerontology, 1980, 35(3), 383-387.

Fielding, J. E. Preventive medicine and the bottom line. Journal of Occupational Medicine, 1979, 21(2), 79-85.

Fielding, J. E. Effectiveness of employee health improvement programs. Journal of Occupational Medicine, 1982, 24(11), 907-916.

CONTINUED

Folkins, C. H., & Sime, W. E. Physical fitness training and mental health. American Psychologist, 1981, 36(4), 373-389.

Harris, L. Fitness in America (Perrier Study). Washington, D. C.: National Center for Health Statistics, 1978.

Haskell, W. L., & Blair, S. N. The physical activity component of health promotion in occupational settings. Public Health Reports, 1980, 95(2), 109-118.

Hedges, J. N. Absence from work - measuring the hours lost. Monthly Labor Review, October 1977, pp. 16-23.

Heinzelmann, F., & Bagley, R. W. Response to physical activity programs and their effects on health behavior. Public Health Reports, 1970, 85(10), 905-911.

Hochstim, J. R., & Renne, K. S. Reliability of response in a sociomedical population study. Public Opinion Quarterly, 1971-72, 35, 69-79.

Howard, J., & Mikalachki, A. Fitness and employee productivity. Canadian Journal of Applied Sport Sciences, 1979, 4(3), 191-198.

Howe, C. Z. Establishing employee recreation programs: a humane rationale. Leisure Today, October 1983, p. 34.

Jette, A. M., Cummings, M., Brock, B. M., Phelps, M. C., & Naessens, J. The structure and reliability of health belief indices. Health Services Research, 1981, 16(1), 81-98.

Kannel, W. B. Habitual level of physical activity and the risk of coronary heart disease: Framingham. Canadian Medical Association Journal, 1967, 96, 811-812.

Katzell, R. A., Yankelovich, D., Fein, M., Ornati, D. A., & Nash, A. Work, productivity and job satisfaction. New York: The Psychological Corporation, 1975.

Kondrasuk, J. Company physical fitness programs: salvation or fad?, Personnel Administrator, November 1980, pp. 47-60.

CONTINUED

Korb, L. Making the volunteer force work. Defense 82, January 1982, pp. 2-11.

LaPorte, R. E., Kuller, L. H., Kupfer, D. J., McPartland, R. J., Matthews, G. & Caspersen, C. An objective measure of physical activity for epidemiologic research. American Journal of Epidemiology, 1979, 109(2), 158-168.

Leonardson, G. R., & Gargiulo, R. M. Self-perception and physical fitness. Perceptual and Motor Skills, 1978, 46, 338. (Abstract)

Linden, V. Absence from work and physical fitness. British Journal of Industrial Medicine, 1969, 26, 47-53.

Luigs, C. F. Physical fitness in the United States Air Force. (ACSC Research Study L952p), Maxwell AFB, Al: Air Command and Staff College, May 1972.

Meltzer, J. W., & Hochstim, J. R. Reliability and validity of survey data on physical health. Public Health Reports, 1970, 85(12), 1075-1086.

Muchinsky, P. M. Employee absenteeism: a review of the literature. Journal of Vocational Behavior, 1977, 10, 316-340.

National Center for Health Statistics: Health practices among adults: United States, 1977, by C. A. Schoenborn and K. M. Danchik, Advanced Data from Vital and Health Statistics. No. 64. DHHS Pub. No. (PHS) 81-1850. Public Health Service. Hyattsville, MD., 1980.

National Center for Health Statistics: Basic data from wave I of the national survey of personal health practices and consequences: United States, 1979, by C. A. Schoenborn, K. M. Danchik and J. Elinson. Vital and Health Statistics. Series 15, No. 2. DHHS Pub. No. (PHS) 81-1163. Public Health Service. Washington, D.C., Government Printing Office, 1981.

National Center for Health Statistics: Public use data tape documentation wave I and wave II of the national survey of

CONTINUED

personal health practices and consequences 1979-1980, by P. M. Golden. Public Health Service. Hyattsville, Md., 1982. (a)

National Center for Health Statistics: Response rates and nonresponse bias in the national survey of personal health practices and consequences, United States, 1980, by C. A. Schoenborn and T. F. Drury. Working Paper Series No. 12, 1982. (b)

Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K., & Bent, D. H. Statistical package for the social sciences, (2nd ed.). New York: McGraw-Hill Book Company, 1975.

Oliver, P. L. Employee health enhancement: a new corporate challenge. Arthur D. Little Decision Resources Special Management Study, Cambridge, Ma., 1982.

Paffenbarger, R. S., Wing, A. L., & Hyde, R. T. Physical activity as an index of heart attack risk in college alumni. American Journal of Epidemiology, 1978, 108, 161-175.

Palmore, E. Physical, mental and social factors in predicting longevity. Gerontologist, 1969, 9, 103-108.

Powell, R. R., & Pohndorf, R. H. Comparison of adult exercisers and non-exercisers on fluid intelligence and selected physiological variables. Research Quarterly, 1971, 42, 70-77.

Pravosudov, V. P. Effects of physical exercise on health and economic efficiency. In F. Landry & W. R. Orban (eds), Physical activity and human well-being (Vol 1). Miami, Fl.: Symposia Specialists, 1978, 261-270.

President's Council on Physical Fitness & Sports. Health and fitness: the corporate view. Special Report, Washington, D.C., undated.

Public Health Service. Physical fitness and exercise. Public Health Reports Supplement, September-October 1983, 155-167.

CONTINUED

Pyle, R. L. Performance measures for a corporate fitness program. Human Resource Management, Fall 1979, pp. 26-30.

Reagan, R. W. In U.S. Department of the Army. The Individual's Handbook on Physical Fitness. Army Pamphlet 350-18. Washington, D.C.: Government Printing Office, 1983.

Saltin, B., Blomqvist, G., Mitchell, J. H., Johnson, R. C., Wildenthal, K., & Chapman, C. B. Response to exercise after bedrest and after training. Circulation, 1968, 38, 1-55.

Shephard, R. J. A brief bibliography on fatigue and fitness. Journal of Occupational Medicine, 1974, 16(12), 804-808.

Shephard, R. J., Cox, M., & Corey, P. Fitness program participation: its effect on worker performance. Journal of Occupational Medicine, 1981, 23(5), 359-363.

Spurr, G. B., Barac-Nieto, M., & Maksud, M. G. Productivity and maximal oxygen consumption in sugarcane cutters. The American Journal of Clinical Nutrition, 1977, 30, 316-321.

Spurr. G. B., Maksud, M. G., & Barac-Nieto, M. Energy expenditure, productivity, and physical work capacity of sugarcane loaders. The American Journal of Clinical Nutrition, 1977, 30, 1740-1746.

Stremel, R. W., Convertion, V. A., & Greenleaf, J. E. Cardiorespiratory deconditioning with static and dynamic leg exercise during bed rest. Journal of Applied Physiology, 1976, 41 905-909.

Suominen-Troyer, S. M. Impact of changes in physical fitness on the effectiveness of decision making (Doctoral dissertation, Purdue University, 1982). Dissertation Abstracts International, 1983, 43, 4102B.

Tuttle, T. C. Productivity measurement methods: classification, critique and implications for the Air Force (AFHRL-TR-81-9). College Park, Md.: University of Maryland, 1981.

U.S. Department of Defense. Physical Fitness and Weight Control.

CONTINUED

DoD Instruction 1308.1. Washington D.C.: Government Printing Office, 1981.

U.S. Department of Defense. Productivity enhancement, measurement, and evaluation - policies and responsibilities. DoD Instruction 5010.34. Washington D.C.: Government Printing Office, 1979.

U.S. Department of the Air Force. Air Force physical fitness program. AF Regulation 35-11. Washington D.C.: Government Printing Office, 1981.

U.S. Department of the Air Force. Air Force productivity enhancement program. AF Regulation 25-3. Washington, D.C.: Government Printing Office, 1982.

U.S. Department of the Air Force: Air Force Manpower and Personnel Center (MPCASD). Air Force enhanced aerobics program, talking papers. Randolph AFB, Tx., 1983.

U.S. Department of the Air Force: Air Force Manpower and Personnel Center (MPCASD). Air Force health survey (SCN 77-62), talking papers. Randolph AFB, Tx., 1977.

U.S. Department of the Air Force: Air University. Air university compendium of research topics - academic year 1983-84. Maxwell Air Force Base, Al., 1983.

Van Orman, J. R., & Langford, C. Can we survive and win? Engineering and Services Quarterly, Spring 1982, pp. 14-18.

Wheeler, B. SSgt, USAF. Assistant for Public Affairs, Manpower and Personnel, HQ U.S. Air Force, Washington, D.C. Telecon. 1 February 1984.

World Health Organization. Constitution of the world health organization. World Health Organization, Geneva, 1978, Annex I.

Wilbur, C. S. Live for life: an epidemiological evaluation of a comprehensive health promotion program. Johnson & Johnson Technical Report. New Brunswick, N.J., 1984.

CONTINUED

Wiley, J. A., & Camacho, T. C. Life-style and future health: evidence from the alameda county study. Preventive Medicine, 1980, 9, 1-21.

Wilson, R. W., & Elinson, J. National survey of personal health practices and consequences: background, conceptual issues, and selected findings. Public Health Reports, 1981, 96(3), 218-237.

APPENDICES

APPENDIX

A

USAF REQUEST FOR PHYSICAL FITNESS RESEARCH

TOPIC: RELATIONSHIP BETWEEN EXERCISE AND SUCCESS IN THE AIR FORCE

SCOPE: In 1980-81, Presidential and OSD interest in the level of fitness of military members stimulated an AFMPC in-depth study of the current Air Force Fitness Regulation. As a part of that study, AFMPC hosted a MAJCOM workshop on Fitness, 18-22 Oct 82. The workshop recommended a revitalized fitness program for the Air Force based upon the basic premise that improved fitness of Air Force members would contribute to readiness and improve quality of life and image. A proposal for an enhanced fitness program currently is being reviewed by the physiological benefits of regular aerobic exercises (fitness) are well documented. [sic]* However, research does not prove but only suggests the psychological benefits, the possible increase in productivity, and overall success of those who exercise regularly. Air Force research is needed to substantiate the importance of fitness to readiness and professional and personal success. Preliminary information is available through the Air Force Special Office on Fitness.

SOURCE: Captain Bobbie Butler, HQ AFMPC/MPCASD, Autovon 487-3934 (Air University Compendium of Research Topics, 1983, p. 34).

* This passage should have read: "A proposal for an enhanced fitness program currently is being reviewed by the *Air Force Chief of Staff (Mar 83). The* physiological benefits..." (Wheeler, 1984).

APPENDIX

B

RESEARCH PROPOSAL

FOR

SURVEY ANALYSES

PREVENTIVE MEDICINE
AND
BIOMETRICS

UNIFORMED SERVICES UNIVERSITY
OF THE
HEALTH SCIENCES
SCHOOL OF MEDICINE
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814

TEACHING HOSPITALS
WALTER REED ARMY MEDICAL CENTER
NATIONAL NAVAL MEDICAL CENTER
MALCOLM GROW AIR FORCE MEDICAL CENTER
WILFORD HALL AIR FORCE MEDICAL CENTER

17 September 1982

MEMORANDUM FOR LT COL RISH, ACSC/EDX

SUBJECT: Physical Activity and Air Force Productivity

My description of subject project follows.

Goal: To analyze the relationship between the physical activity of Air Force members and their productivity (actually surrogate measures of productivity will be utilized; these include work-loss days, days of hospitalization, and number of doctor visits).

Data Available:

1. The Air Force Health Survey conducted in 1977 by MPC with 6,675 respondents. This data will be used to characterize the activity levels of Air Force personnel by age, sex, rank, AFSC, etc.

2. The 1977 National Center for Health Statistics Health Interview Survey Health Practices Supplement with 22,842 respondents. Detailed estimates of work-loss and health care utilization can be made for various demographic groups.

3. The 1979 National Survey of Health Practices and Health Consequences with 3,025 respondents. Detailed information on exercise are included which can be related to health care utilization. The results of this analysis will be compared to those from data set (2) which has larger numbers but less detail on physical activity.

4. Hospitalization and outpatient visit data for the Air Force from the Air Force Medical Service Center. These data constitute an aggregate for comparison with estimates from U.S. data.

Research Plan:

The Air Force and U.S. samples would each be divided into three or four groups based on activity levels. Estimates of work-loss and health care utilization would be made based on age, sex and level of activity for the U.S. population. Multiple regression would be used to determine other variables (e.g., education) that need to be controlled. U.S. results would be applied to the age, sex and activity specific groups of the Air Force population in order to estimate Air Force work-loss and health care utilization by level of physical activity. Results could be expressed both in terms of numerical and percentage differences. The final step would be to translate work-loss and health care utilization figures into dollar values.

This would be original work in an area that has received little attention. Do not hesitate to contact me at AUTOVON if I can be of further assistance.

Harry P. Wetzler
Lt Col, USAF, MC
Assistant Professor
Division of Environmental and
Occupational Health
Department of Preventive Medicine/Biometrics

APPENDIX

C

NATIONAL HEALTH INTERVIEW SURVEY

HEALTH HABITS SUPPLEMENT

SELECTED SURVEY QUESTIONS AND POSSIBLE ANSWERS*

SHORT TITLE	ITEM NUMBER	QUESTION
Bed Days	5	During the past 2 weeks, how many days did you stay in bed because of any illness or injury? 00........None 01-14.....Number of days
Bed Days/ Year	Generated	Bed days/2 weeks x 26 weeks/year=Bed days/year
Work Loss/ Year	5b	During the past 12 months, how many days did illness or injury keep you from work? 00........None 01-96.....1-96 days 97........97+ days 98........Unknown Blank.....Not applicable (Under 17)
Work Loss	6	During the past 2 weeks, how many days did illness or injury keep you from work? (For females: not counting work around the house?) 00........None(or under 6 years of age) 01-14.....Number of days

CONTINUED

School Loss	7	During the past 2 weeks, how many days did illness or injury keep you from school? 00........None(or under 6 years of age) 01-14.....Number of days
Hospi- tal Days	8	During the past 2 weeks, about how many nights were you in the hospital? 00........None 00-14.....Number of days
Hospi- tal Days/ Year	Gener- ated	During the past 12 months, about how many nights were you in the hospital? 00........None 000-365...Number of days
Number Doctor Visits	18a	During the past 12 months, how many times did you see or talk to a medical doctor about your own health? Please exclude any doctors you may have seen while you were a patient in a hospital. 00........None or Unknown 001-997...Number of visits
Physical Activity	H1-9	How would you compare your level of physical activity with other people your age? 1.........More active 2.........Less active 3.........Same 4.........Other 5.........Unknown
Health Index 5	CV**	5 Health Habits Score 0.........0 Health habits

CONTINUED

		1.........1 Health habits
		2.........2 Health habits
		3.........3 Health habits
		4.........4 Health habits
		5.........5 Health habits
Health Index 7	CV***	7 Health Habits Score
		0.........0 Health habits
		1.........1 Health habits
		2.........2 Health habits
		3.........3 Health habits
		4.........4 Health habits
		5.........5 Health habits
		6.........6 Health habits
		7.........7 Health habits

* Source: NCHS, 1980.

** Constructed variable of five health habit variables: sleep, weight-height, alcohol consumption, smoking and physical activity.

*** Constructed variable of seven health habit variables: sleep, weight-height, alcohol consumption, smoking, physical activity, breakfast and snacking.

APPENDIX

D

AIR FORCE WEIGHTING LOGIC

```
1. SELECT IF (AGE LE 54 AND (USUACTY EQ 1 OR USUACTY EQ 4) AND
             ACLIMCC EQ 4 AND EDUC GE 7 AND EDUC LE 11 AND
             ((SEX EQ 1 AND HT GE 60 AND HT LE 80 AND WGHT GE
             100 AND WGHT LE 254) OR (SEX EQ 2 AND HT GE 58 AND
             HT LE 80 AND WGHT GE 87 AND WGHT LE 216)))
2.  RECODE   SEX (1=0) (2=1)
3.  RECODE   EDUC (1=0) (2=2.5) (3=5.5) (4=7.5) (5=10) (6=12)
             (7=14) (8=17)
4.  COMPUTE  N=4000
5.  COMPUTE  MALEN=.931*N
6.  COMPUTE  FEMN=.069*N
7.  COMPUTE  MFACT=MALEN/6070
8.  COMPUTE  FFACT=FEMN/450
9.  COMPUTE  AFWT=999
10. IF       (AGE LE 24 AND EDUC EQ 12 AND SEX EQ 0)
             AFWT=1510/337*MFACT
11. IF       (AGE GE 25 AND AGE LE 34 AND EDUC EQ 12 AND
             SEX EQ 0) AFWT=706/587*MFACT
12. IF       (AGE GE 35 AND AGE LE 44 AND EDUC EQ 12 AND SEX EQ
             0) AFWT =399/451*MFACT
13. IF       (AGE GE 45 AND EDUC EQ 12 AND SEX EQ 0)
             AFWT=25/401*MFACT
14. IF       (AGE LE 24 AND EDUC GT 12 AND EDUC LT 16
             AND SEX EQ 0) AFWT=926/288*MFACT
15. IF       (AGE GE 25 AND AGE LE 34 AND EDUC GT 12
             AND EDUC LT 16 AND SEX EQ 0) AFWT=821/372*MFACT
16. IF       (AGE GE 35 AND AGE LE 44 AND EDUC GT 12
             AND EDUC LT 16 AND SEX EQ 0) AFWT=466/170*MFACT
17. IF       (AGE GE 45 AND EDUC GT 12 AND EDUC LT 16
             AND SEX EQ 0) AFWT=47/133*MFACT
18. IF       (AGE LE 24 AND EDUC GE 16 AND SEX EQ 0)
             AFWT=96/103*MFACT
19. IF       (AGE GE 25 AND AGE LE 34 AND EDUC GE 16
             AND SEX EQ 0) AFWT=625/515*MFACT
20. IF       (AGE GE 35 AND AGE LE 44 AND EDUC GE 16
             AND SEX EQ 0) AFWT=378/300*MFACT
```

CONTINUED

```
21. IF        (AGE GE 45 AND EDUC GE 16 AND SEX EQ 0)
              AFWT=71/239*MFACT
22. IF        (AGE LE 24 AND EDUC EQ 12 AND SEX EQ 1)
              AFWT=180/370*FFACT
23. IF        (AGE GE 25 AND AGE LE 34 AND EDUC EQ 12
              AND SEX EQ 1) AFWT=38/498*FFACT
24. IF        (AGE GE 35 and AGE LE 44 AND EDUC EQ 12
              AND SEX EQ 1) AFWT=3.38/360*FFACT
25. IF        (AGE GE 45 AND EDUC EQ 12 AND SEX EQ 1)
              AFWT=0.016/401*FFACT
26. IF        (AGE LE 24 AND EDUC GT 12 AND EDUC LT 16
              AND SEX EQ 1) AFWT=106/300*FFACT
27. IF        (AGE 25 AND AGE LE 34 AND EDUC GT 12
              AND EDUC LT 16 AND SEX EQ 1) AFWT=60/263*FFACT
28. IF        (AGE GE 35 AND AGE LE 44 AND EDUC GT 12
              AND EDUC LT 16 AND SEX EQ 1) AFWT=2.64/152*FFACT
29. IF        (AGE GE 45 AND EDUC GT 12 AND EDUC LT 16
              AND SEX EQ 1) AFWT=1.8/104*FFACT
30. IF        (AGE LE 24 AND EDUC GE 16 AND SEX EQ 1)
              AFWT=15/129*FFACT
31. IF        (AGE GE 25 AND AGE LE 34 AND EDUC GE 16
              AND SEX EQ 1) AFWT=34/329*FFACT
32. IF        (AGE GE 35 AND AGE LE 44 AND EDUC GE 16
              AND SEX EQ 1) AFWT=7/138*FFACT
33. IF        (AGE GE 45 AND EDUC GE 16 AND SEX EQ 1 )
              AFWT=2.18/93*FFACT
34. ASSIGN    MISSING  AFWT (999)
```

EXPLANATION OF CODES

CODE	MEANING
USUACTY	Usual activity
ACLIM	Activity limitation
EDUC	Education
HT	Height
WGHT	Weight
MALEN	Factor weighting N by approximate percentage of males in USAF in 1977

CONTINUED

FEMN	Factor weighting N by approximate percentage of females in USAF in 1977
MFACT	Weighting factor (MALEN) divided by number of males in 1977 USAF Health Survey
FFACT	Weighting factor (FEMN) divided by number of females in 1977 USAF Health Survey
AFWT	Weighting factor to match national survey respondents to USAF demographic characteristics

APPENDIX

E

NATIONAL SURVEY OF PERSONAL HEALTH

PRACTICES AND CONSEQUENCES

SELECTED SURVEY QUESTIONS AND POSSIBLE ANSWERS*

SHORT TITLE	ITEM NUMBER	QUESTION
Number Doctor Visit	21	During the past 12 months, that is, since (Date one year ago) about how many times did you see or speak to medical doctor about your own health? Please exclude any doctor you may have seen while you were a patient in a hospital. 00-96.....Number of visits 97........97 or more visits 98........Don't know
Physical Activity	45	How would you compare your level of physical activity with other people your age? Would you say you are: 1........Much less active 2........Somewhat less active 3........Somewhat more active 4........Much more physically active 5........Respondent insists "Just as Active" 8........Don't know
Exercise Need	48	Do you feel that you get as much exercise as you need, or less than you need? 1........As much as you need 2........Less than you need

CONTINUED

		3........Don't know
Hospital Days	57	Altogether, how many nights were you in the hospital since (Date One Year Ago)? 00-97....Number of nights 98.......Don't know 99.......Refused Blank ...Not applicable
Bed Days	64	During the past 12 months, that is, about how many days did illness or injury keep you in bed all or most of the day? 1........None 2........1-7 days (up to 1 week) 3........8-30 days (more than 1 week) 4........31-180 days (more than 1 month up to 6 months) 5........181 days or more (more than 6 months) 8........Don't know
Activity Levels	115	Please tell me how often you participate in these activities. First, how often do you:
Swim	115	Go swimming in the summer? 1........Never 2........Rarely 3........Sometimes 4........Often
Walk	115	Take long walks? 1........Never 2........Rarely 3........Sometimes 4........Often

CONTINUED

Active Hobby	115	Work on a physically active hobby such as dancing or gardening? 1........Never 2........Rarely 3........Sometimes 4........Often
Jog	115	Go jogging or running? 1........Never 2........Rarely 3........Sometimes 4........Often
Bike	117	Ride a bicycle? 1........Never 2........Rarely 3........Sometimes 4........Often
Calis-thenics	117	Do calisthenics or physical exercise? 1........Never 2........Rarely 3........Sometimes 4........Often
Other Sports	117	Participate in any other active sports I haven't already mentioned? 1........Never 2........Rarely 3........Sometimes 4........Often
Exercise	115,116	Physical activity recode 00.......Not Active 16.......Active 32.......Unknown

CONTINUED

Health Index 5	CV**	5 Health Habits Score 0......0 Health habits 1......1 Health habits 2......2 Health habits 3......3 Health habits 4......4 Health habits 5......5 Health habits
Health Index 6	CV***	6 Health Habits Score 0......0 Health habits 1......1 Health habits 2......2 Health habits 3......3 Health habits 4......4 Health habits 5......5 Health habits 6......6 Health habits
Exercise Composite	CV****	Exercise recode: 2 x swim + 2 x walk + active hobby + 2 x jog + 2 x bike + calisthenics + other sports 1...11-21 cumulative points (according to above formula) 2...22-26 cumulative points 3...27-31 cumulative points 4...32-44 cumulative points

* Source: NCHSa, 1982.

** Constructed variable of five health habit variables: sleep, weight-height, alcohol consumption, smoking and physical activity.

*** Constructed variable of six health habit variables: sleep, weight-height, alcohol consumption, smoking, physical activity and breakfast.

**** Special constructed variable applied to U.S. sample population weighted to match the USAF population solely for the purpose of this research paper.

APPENDIX

F

SURVEY STATISTICAL SUMMARIES

CONTINUED

Table A

Analysis of Variance

Lost Workdays for Seven Health Habits Composite

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	1454.542	5	290.908	4.354	.001
Age	12.459	1	12.459	.186	.666
Education	981.012	1	981.012	14.683	.000
Income	.891	1	.891	.013	.908
Geographic Location	95.083	1	95.083	1.423	.233
Marital Status	228.645	1	228.645	3.422	.064
Main Effects	1390.017	6	231.670	3.467	.002
7 Habits	1243.313	5	248.663	3.722	.002
Sex	218.544	1	218.544	3.271	.071
2-Way Interactions	229.421	5	45.884	.687	.633
7 Habits Sex	229.421	5	45.884	.687	.633
Explained	3073.979	16	192.124	2.876	.000
Residual	240658.998	3602	66.813		
Total	243732.977	3618	67.367		

CONTINUED

Table B

Analysis of Variance

Hospital Days for Seven Health Habits Composite

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	43.201	5	8.640	1.776	.115
Age	.018	1	.018	.004	.951
Education	20.205	1	20.205	4.152	.042
Income	4.106	1	4.106	.844	.358
Geographic Location	.096	1	.096	.020	.889
Marital Status	19.655	1	19.655	4.039	.045
Main Effects	82.459	7	11.780	2.421	.018
7 Habits	56.671	5	11.334	2.329	.040
Sex	21.014	1	21.014	4.318	.038
Race	9.393	1	9.393	1.930	.165
2-Way Interactions	23.156	11	2.105	.433	.942
7 Habits Sex	19.257	5	3.851	.791	.556
7 Habits Race	2.253	5	.451	.093	.993
Sex Race	1.461	1	1.461	.300	.584
3-WAY Interactions	7.405	5	1.481	.304	.910
7 Habits Sex Race	7.405	5	1.481	.304	.910
Explained	156.220	28	5.579	1.147	.271
Residual	17805.744	3659	4.866		
Total	17961.964	3687	4.872		

CONTINUED

Table C

Analysis of Variance

Doctor Visits for 7 Health Habits Composite

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	419.165	5	83.833	4.080	.001
Age	18.685	1	18.685	.909	.340
Education	6.367	1	6.367	.310	.578
Income	5.844	1	5.844	.284	.594
Geographic Location	202.233	1	202.233	9.843	.002
Marital Status	134.199	1	134.199	6.532	.011
Main Effects	1081.657	7	154.522	7.521	.000
7 Habits	230.245	5	46.049	2.241	.048
Sex	884.303	1	884.303	43.042	.000
Race	8.513	1	8.513	.414	.520
2-Way Interactions	94.670	11	8.606	.419	.949
7 Habits Sex	56.009	5	11.202	.545	.742
7 Habits Race	31.759	5	6.352	.309	.908
Sex Race	3.123	1	3.123	.152	.697
3-Way Interactions	26.239	5	5.248	.255	.937
7 Habits Sex Race	26.239	5	5.248	.255	.937
Explained	1621.731	28	57.919	2.819	.000
Residual	75174.790	3659	20.545		
Total	76796.521	3687	20.829		

CONTINUED

Table D

Analysis of Variance

Lost Workdays for Five Health Habits Composite

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	1433.637	5	286.727	4.242	.001
Age	9.245	1	9.245	.137	.712
Education	984.826	1	984.826	14.571	.000
Income	.891	1	.891	.013	.909
Geographic Location	89.483	1	89.483	1.324	.250
Marital Status	221.354	1	221.354	3.275	.070
Main Effects	877.751	5	175.550	2.597	.024
5 Habits	571.377	3	190.459	2.818	.038
Sex	148.176	1	148.176	2.192	.139
Race	214.992	1	214.992	3.181	.075
2-Way Interactions	156.494	7	22.356	.331	.940
5 Habits Sex	11.488	3	3.829	.057	.982
5 Habits Race	79.696	3	26.565	.393	.758
Sex Race	64.153	1	64.153	.949	.330
3-Way Interactions	58.530	3	19.510	.289	.834
5 Habits Sex Race	58.530	3	19.510	.289	.834
Explained	2526.410	20	126.321	1.869	.011
Residual	241289.477	3570	67.588		
Total	243815.887	3590	67.915		

CONTINUED

Table E

Analysis of Variance

Hospital Days for Five Health Habits Composite

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	39.997	5	7.999	1.729	.125
Age	.008	1	.008	.002	.967
Education	17.641	1	17.641	3.813	.051
Income	2.022	1	2.022	.437	.509
Geographic Location	1.153	1	1.153	.249	.618
Marital Status	19.244	1	19.244	4.159	.042
Main Effects	62.171	5	12.434	2.688	.020
5 Habits	35.868	3	11.956	2.584	.052
Sex	18.941	1	18.941	4.094	.043
Race	11.913	1	11.913	2.575	.109
2-Way Interactions	22.529	7	3.218	.696	.676
5 Habits Sex	15.476	3	5.159	1.115	.342
5 Habits Race	5.696	3	1.898	.410	.746
Sex Race	1.292	1	1.292	.279	.597
3-Way Interactions	8.094	3	2.698	.583	.626
5 Habits Sex Race	8.094	3	2.698	.583	.626
Explained	132.792	20	6.640	1.435	.095
Residual	16836.221	3639	4.627		
Total	16969.013	3659	4.638		

CONTINUED

Table F

Analysis of Variance

Doctor Visits for Five Health Habits Composite

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	477.009	5	95.402	4.623	.000
Age	22.014	1	22.014	1.067	.302
Education	8.149	1	8.149	.395	.530
Income	9.693	1	9.693	.470	.493
Geographic Location	216.551	1	216.551	10.493	.001
Marital Status	160.627	1	160.627	7.784	.005
Main Effects	1052.791	5	210.558	10.203	.000
5 Habits	215.099	3	71.700	3.474	.015
Sex	841.684	1	841.684	40.786	.000
Race	10.548	1	10.548	.511	.475
2-Way Interactions	154.561	7	22.080	1.070	.380
5 Habits Sex	38.856	3	12.952	.628	.597
5 Habits Race	112.723	3	37.574	1.821	.141
Sex Race	4.316	1	4.316	.209	.647
3-Way Interactions	17.917	3	5.972	.289	.833
5 Habits Sex Race	17.917	3	5.972	.289	.833
Explained	1702.277	20	85.114	4.124	.000
Residual	75097.280	3639	20.637		
Total	76799.558	3659	20.989		

CONTINUED

Table 6

Analysis of Variance

Lost Workdays for Five Health Habits
Ages 30-54

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	288.848	5	57.770	.809	.543
Age	69.800	1	69.800	.978	.323
Education	158.218	1	158.218	2.216	.137
Income	2.711	1	2.711	.038	.846
Geographic Location	1.826	1	1.826	.026	.873
Marital Status	15.608	1	15.608	.219	.640
Main Effects	818.132	4	204.533	2.864	.022
5 Habits	790.986	3	263.662	3.692	.012
Sex	38.634	1	38.634	.541	.462
2-Way Interactions	16.631	3	5.544	.078	.972
5 Habits Sex	16.631	3	5.544	.078	.972
Explained	1123.609	12	93.634	1.311	.205
Residual	95754.118	1341	71.405		
Total	96877.728	1353	71.602		

CONTINUED

Table H

Analysis of Variance

Hospital Days by Jogging Frequency

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	11.489	5	2.298	1.121	.347
Age	.423	1	.423	.206	.650
Education	7.150	1	7.150	3.488	.062
Income	2.290	1	2.290	1.117	.291
Geographic Location	.969	1	.969	.473	.492
Marital Status	.340	1	.340	.166	.684
Main Effects	21.171	4	5.293	2.582	.036
Jog	9.508	2	4.754	2.319	.099
Sex	7.927	1	7.927	3.867	.050
Race	2.809	1	2.809	1.370	.242
2-Way Interactions	5.807	5	1.017	.496	.779
Jog Sex	3.896	2	1.948	.950	.387
Jog Race	1.030	2	.515	.251	.778
Sex Race	.018	1	.018	.009	.926
3-Way Interactions	2.810	2	1.405	.685	.504
Jog Sex Race	2.810	2	1.405	.685	.504
Explained	40.557	16	2.535	1.237	.233
Residual	1875.742	915	2.050		
Total	1916.299	931	2.058		

CONTINUED

Table I

Analysis of Variance

Doctor Visits by Jogging Frequency

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	86.770	5	17.354	2.336	.040
Age	63.160	1	63.160	8.503	.004
Education	3.455	1	3.455	.465	.495
Income	6.686	1	6.686	.900	.343
Geographic Location	3.200	1	3.200	.431	.512
Marital Status	21.610	1	21.610	2.909	.088
Main Effects	219.135	4	54.784	7.375	.000
Jog	60.193	2	30.097	4.052	.018
Sex	162.432	1	162.432	21.867	.000
Race	1.048	1	1.048	.141	.707
2-Way Interact.ons	10.480	5	2.096	.282	.923
Jog Sex	5.814	2	2.907	.391	.676
Jog Race	2.855	2	1.427	.192	.825
Sex Race	1.127	1	1.127	.152	.697
3-Way Interactions	2.345	2	1.172	.158	.854
Jog Sex Race	2.345	2	1.172	.158	.854
Explained	318.730	16	19.921	2.682	.000
Residual	6796.789	915	7.428		
Total	7115.520	931	7.643		

CONTINUED

Table J

Analysis of Variance

Bed Days for Six Health Habits

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	533.352	5	106.670	2.751	.018
Age	138.442	1	138.442	3.570	.059
Education	33.182	1	33.182	.856	.355
Income	.210	1	.210	.005	.941
Geographic Location	99.169	1	99.169	2.557	.110
Marital Status	64.050	1	64.050	1.652	.199
Main Effects	592.515	6	98.752	2.547	.019
6 Health Habits	493.517	4	123.379	3.182	.013
Sex	56.398	1	56.398	1.454	.228
Race	48.495	1	48.495	1.251	.264
2-Way Interactions	173.768	9	19.308	.498	.876
6 Habits Sex	128.741	4	32.185	.830	.506
6 Habits Race	31.675	4	7.919	.204	.936
Sex Race	.182	1	.182	.005	.945
3-Way Interactions	44.073	4	11.018	.284	.888
6 Habits Sex Race	44.073	4	11.018	.284	.888
Explained	1343.707	24	55.988	1.444	.078
Residual	34433.685	888	38.777		
Total	35777.392	912	39.230		

CONTINUED

Table K

Analysis of Variance

Hospital Days for Physical Activity Level (aggregated)

Source of Variation		Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates		12.306	5	2.461	1.193	.311
Age		.579	1	.579	.281	.596
Education		7.808	1	7.808	3.783	.052
Income		2.415	1	2.415	1.170	.280
Geographic Location		.916	1	.916	.444	.505
Marital Status		.347	1	.347	.168	.682
Main Effects		16.627	3	5.542	2.686	.045
Physical Activity		5.765	1	5.765	2.793	.095
Sex		6.123	1	6.123	2.967	.085
Race		3.459	1	3.459	1.676	.196
2-Way Interactions		2.559	3	.853	.413	.743
Physical Activity	Sex	.375	1	.375	.182	.670
Physical Activity	Sex	2.027	1	2.027	.982	.322
Sex	Race	.014	1	.014	.007	.935
3-Way Interactions		.407	1	.407	.197	.657
Phys. Act. Sex	Race	.407	1	.407	.197	.657
Explained		31.900	12	2.658	1.288	.220
Residual		1877.975	910	2.064		
Total		1909.875	922	2.071		

CONTINUED

Table L

Analysis of Variance

Hospital Days for Jogging Frequency (aggregated)

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	11.489	5	2.298	1.124	.346
Age	.423	1	.423	.207	.649
Education	7.150	1	7.150	3.499	.062
Income	2.290	1	2.290	1.120	.290
Geographic Location	.969	1	.969	.474	.491
Marital Status	.340	1	.340	.166	.683
Main Effects	20.807	3	6.936	3.394	.017
Jog	9.145	1	9.145	4.474	.035
Sex	7.754	1	7.754	3.794	.052
Race	2.616	1	2.616	1.280	.258
2-Way Interactions	4.124	3	1.375	.673	.569
Jog Sex	3.151	1	3.151	1.542	.215
Jog Race	.634	1	.634	.310	.578
Sex Race	.064	1	.064	.031	.860
3-Way Interactions	1.602	1	1.602	.784	.376
Jog Sex Race	1.602	1	1.602	.784	.376
Explained	38.023	12	3.169	1.550	.101
Residual	1878.276	919	2.044		
Total	1916.299	931	2.058		

CONTINUED

Table M

Analysis of Variance

Doctor Visits for Exercise Frequency (aggregated)

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif. of F
Covariates	86.770	5	17.354	2.335	.040
Age	63.160	1	63.160	8.499	.004
Education	3.455	1	3.455	.465	.495
Income	6.686	1	6.686	.900	.343
Geographic Location	3.200	1	3.200	.431	.512
Marital Status	21.610	1	21.610	2.908	.088
Main Effects	189.594	3	63.198	8.504	.000
Exercise Composite	30.652	1	30.652	4.125	.043
Sex	155.918	1	155.918	20.981	.000
Race	2.176	1	2.176	.293	.589
2-Way Interactions	7.920	3	2.640	.355	.785
Exercise Sex	1.811	1	1.811	.244	.622
Exercise Race	4.026	1	4.026	.542	.462
Sex Race	2.120	1	2.120	.285	.593
3-Way Interactions	1.925	1	1.925	.259	.611
Exercise Sex Race	1.925	1	1.925	.259	.611
Explained	286.209	12	23.851	3.210	.000
Residual	6829.311	919	7.431		
Total	7115.520	931	7.643		

GLOSSARY

Acronym	Explanation
AFMPC	Air Force Manpower and Personnel Center
ANOVA	Analysis of Variance subprogram of the SPSS (see below).
DHHS	U.S. Department of Health and Human Services.
DOD	Department of Defense.
NCHS	U.S. National Center for Health Statistics, a component of the Public Health Service and, in turn, the DHHS (see above).
NHIS	U.S. National Health Interview Survey, administered annually by the NCHS.
NSPHPC	U.S. National Survey of Personal Health Practices and Consequences, administered in 1979 and 1980 by the NCHS.
PCPFS	President's Council on Physical Fitness and Sports.
SPSS	Statistical Package for the Social Sciences, an automated statistical analysis program.
USAF	United States Air Force.
VO_{2max}	Volume of maximum oxygen consumption in a given time period.